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RENSELAER GRIT PLATEAU, NEW YORK

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THE RENSSELAER GRIT PLATEAU IN NEW YORK,

BY

T. NELSON DALE.

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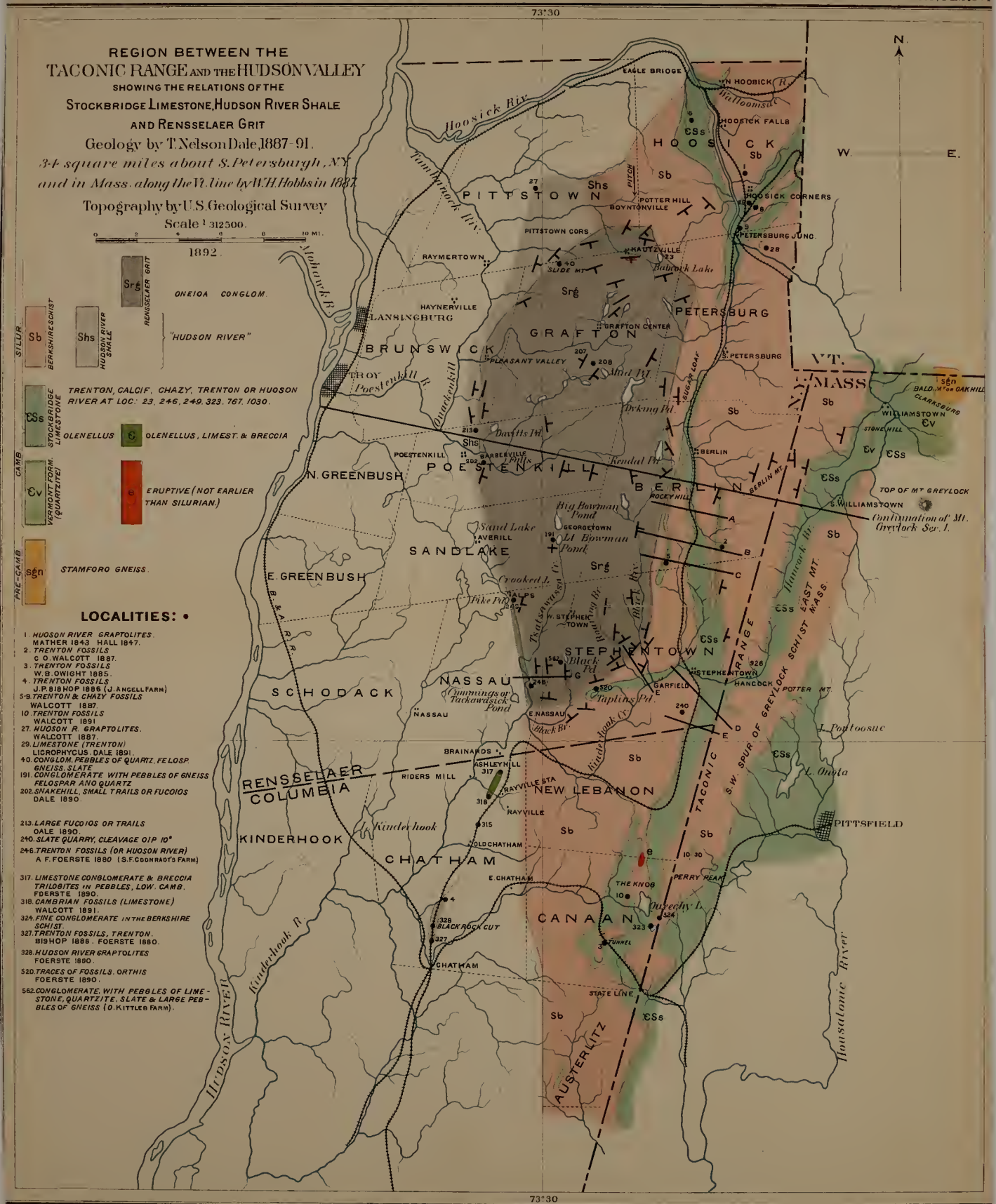
73°30
REGION BETWEEN THE
TACONIC RANGE AND THE HUDSON VALLEY
SHOWING THE RELATIONS OF THE
STOCKBRIDGE LIMESTONE, HUDSON RIVER SHALE
AND RENSSELAER GRIT
Geology by T. Nelson Dale, 1887-91.
34 square miles about S. Petersburgh, N.Y.
and in Mass. along the V. line by W.H. Hobbs in 1887.
Topography by U.S. Geological Survey
Scale 1:312500.
1892.
Srg RENSSELAER GRIT
ONEIOA CONGLOM.
Sb BERKSHIRE SCHIST
Shs HUDSON RIVER SHALE
"HUDSON RIVER"
SILUR.
TRENTON, CALCIF., CHAZY, TRENTON OR HUDSON RIVER AT LOC.: 23, 246, 249, 323, 767, 1030.
CSs STOCKBRIDGE LIMESTONE
OLENELLUS
OLENELLUS, LIMEST. & BRECCIA
CAMB.
Cv VERMONT FORM. (QUARTZITE)
ERUPTIVE (NOT EARLIER THAN SILURIAN)
PRE-CAMB.
sgn STAMFORD GNEISS.
LOCALITIES:
1. HUDSON RIVER GRAPTOLITES. MATHER 1843 HALL 1847.
2. TRENTON FOSSILS C. O. WALCOTT 1887.
3. TRENTON FOSSILS W. B. DWIGHT 1885.
4. TRENTON FOSSILS J. P. BISHOP 1886 (J. ANGELL FARM)
5-9. TRENTON & CHAZY FOSSILS WALCOTT 1887.
10. TRENTON FOSSILS WALCOTT 1891.
27. HUDSON R. GRAPTOLITES. WALCOTT 1887.
29. LIMESTONE (TRENTON) LICROPHYCUS. DALE 1891.
40. CONGLOM. PEBBLES OF QUARTZ, FELOSP. GNEISS, SLATE
191. CONGLOMERATE WITH PEBBLES OF GNEISS FELOSPAR AND QUARTZ
202. SNAKEHILL, SMALL TRAILS OR FUCOIDS DALE 1890.
213. LARGE FUCOIDS OR TRAILS DALE 1890.
240. SLATE QUARRY, CLEAVAGE DIP 10°
246. TRENTON FOSSILS (OR HUDSON RIVER) A. F. FOERSTE 1880 (S.F. CONRADT'S FARM)
317. LIMESTONE CONGLOMERATE & BRECCIA TRILOBITES IN PEBBLES, LOW. CAMB. FOERSTE 1890.
318. CAMBRIAN FOSSILS (LIMESTONE) WALCOTT 1891.
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327. TRENTON FOSSILS, TRENTON. BISHOP 1888. FOERSTE 1890.
328. HUDSON RIVER GRAPTOLITES FOERSTE 1890.
520. TRACES OF FOSSILS, ORTHIS FOERSTE 1890.
562. CONGLOMERATE, WITH PEBBLES OF LIMESTONE, QUARTZITE, SLATE & LARGE PEBBLES OF GNEISS (O. KITTLE'S FARM).
N.
W.
E.
EAGLE BRIDGE
N. HOOSICK R.
Walloomsac
HOOSICK FALLS
HOOSICK
Hoosick Riv.
Tom Brook Riv.
PITTSTOWN
POTTER HILL
BOYNTONVILLE
HOOSICK CORNERS
PETERSBURG JUNC.
PITTSTOWN CORS.
RAYMERTOWN
KAUTZVILLE
SLIDE MT.
Babcock Lake
Mohawk R.
HAYNERVILLE
LANSINGBURG
PETERSBURG
GRAFTON
GRAFTON CENTER
BRUNSWICK
PLEASANT VALLEY
S. PETERSBURG
VT.
MASS.
TROY
Poestenkill R.
Quackenkill
Mud Pd.
Sugar Loaf
Dyking Pd.
BALD MT. OR OAK HILL
CLARKSBURG
WILLIAMSTOWN
STONE HILL
Davis Pd.
POESTENKILL
BARBERVILLE
Falls
BERLIN
N. GREENBUSH
POESTENKILL
Kendal Pd.
BERLIN MT.
TOP OF MT. GREYLOCK
S. WILLIAMSTOWN
Continuation of Mt. Greylock Sec. I.
ROCKY HILL
Big Bowman Pond
Sand Lake
AVERILL
GEORGETOWN
L. Bowman Pond
SANDLAKE
E. GREENBUSH
Crooked L.
Pike Pd.
Pike Pd. Lake
B. & A. R.R.
W. STEPHENTOWN
Tsatsawassa Cr.
Black Bk.
Hunsinwan Riv.
Hancock Br.
STEPHENTOWN
Black Pd.
HANCOCK
POTTER MT.
EAST MT. MASS.
SCHODACK
NASSAU
Cummings or Tackawasick Pond
GARFIELD
Taplins Pd.
NASSAU
E. NASSAU
Black Bk.
Kinderhook Cr.
L. Pontoosuc
L. Onota
BRAINARDS
ASHLEYHILL
RENSSELAER
COLUMBIA
RIDERS MILL
RAYVILLE STA.
NEW LEBANON
RAYVILLE
PITTSFIELD
L. Kinderhook
KINDERHOOK
OLD CHATHAM
CHATHAM
E. CHATHAM
THE KNOB
PERRY REAM
Quaghy L.
CANAAN
BLACK ROCK CUT
TUNNEL
CHATHAM
STATE LINE
AUSTERLITZ
Hudson River
Kinderhook R.
Housatonic River
TACONIC RANGE
S.W. SPUR OF GREYLOCK SCHIST
73°30

THE RENSSELAER GRIT PLATEAU IN NEW YORK.

By T. Nelson Dale.

TOPOGRAPHICAL.

In going from the western foot of Mount Greylock, in Massachusetts, to the Hudson river valley, there are two points of view at which the traveler's attention is arrested by marked changes in the landscape. One of these is the summit of Berlin mountain[1] on the New York and Massachusetts line (2,804 feet), the highest point west of Mount Greylock. To the north, south, east, and for 5 miles to the west stretches the varied topography so characteristic of the schist and limestone region of Berkshire county, which consists of a more or less parallel succession of hill ranges trending NNE. with deep transverse and branching hollows on both flanks. East and Potter mountains, to the south, belong to this system, being in reality the southwestern continuation of the Greylock mass. To the west, beyond the valley of the Little Hoosick, rises the edge of a plateau or broad, shallow basin, which contrasts with all the rest of the landscape in its nearly uniform level and the absence of the deep east-west incisions. Here and there rise from its surface long, smooth hillocks, less than 300 feet high, and scarcely reaching the altitude of the edge of the plateau itself.

The second point is north of Snake hill (altitude 1,400 feet), 7 miles west of the valley of the Little Hoosick and 8 miles east of the Hudson. On the east a broad basin is seen to rise gently into the low hillocks of the plateau just described, while on the west the aspect is totally different; a steep descent of 600 feet, with a gradual fall of 200 more, then a broad belt of low, undulating drift hills extending to the Hudson, and, in the distance, the massive forms of the Catskills.

We have, then, here three perfectly distinct topographical belts:

That of the Berkshire hills, extending from the Little Hoosick or the Berlin-Stephentown valley at the west foot of the Taconic range to the longitude of Pittsfield, 6 to 7 miles, and indeed 7 miles further, including the Greylock mass, but stopping at the foot of the Hoosac range.

That of the Rensselaer county plateau, from the Berlin-Stephentown valley west to the drop near Poestenkill, a width of 9 miles.

[1] Known in New York as Mount Macomber.

That of the Hudson valley, from the foot of that slope which forms the west edge of the plateau to the Hudson, 7½ miles.

A glance at the contour lines of the Greylock, Berlin, and Troy topographical sheets shows the leading features of these belts. The region east of the Berlin valley is marked by NNE. hill ranges with deep and complex incisions, and an east and west drainage, while the plateau on the west is characterized by its somewhat steep and little broken eastern edge, ranging from 700 to 1,200 feet above the valley, also by its low hillocks, its broad and gentle slopes, its large level spaces, and its many ponds and swamps. At Stephentown the plateau edge turns WSW., and is more broken, forming the line of hills so conspicuous from the Kinderhook about Garfield, and determining the course of that river. A large part of the drainage of the plateau is effected by southward-flowing streams, the Black river, Roaring brook, and Black brook, which pass through these hills, and the Tsatsawassa (Tackawasick) farther west, all of which empty into the Kinderhook.

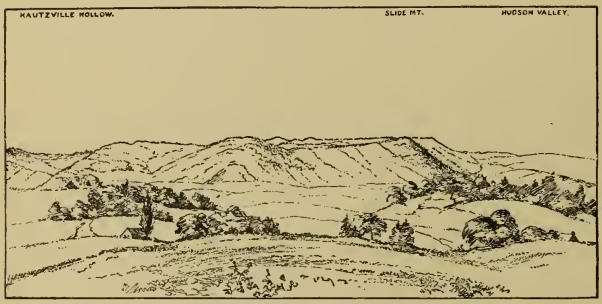


FIG. 18.—Sketch of the northwestern edge of the plateau in Pittstown, taken from a point a little (east of loc. 27 on map (Pl. XCVII.)

The north and northwest edges of the plateau in Pittstown and Grafton closely resemble its southern edge, but are broken only by an inconspicuous tributary of the Tamhanock, which flows into the Hoosick. See Fig. 18. Fig. 19 gives a typical profile of the western edge. The drainage not effected by the southward-flowing streams is carried off by the Poestenkill (Babbling brook) and the Quackenkill, which flow westward, cutting deep gorges through that edge of the plateau, and go unitedly to the Hudson. The entire area of the plateau measures about 175 square miles, covering more than a quarter of Rensselaer county.

An orographic feature which might be expected in a section across the side of the Appalachians is the gradual decline in the heights of the summits from Greylock westward: Greylock, 3,505 feet; Berlin mountain, 2,804 (East mountain, 2,660; Potter mountain, 2,400); the highest

point on the east side of the plateau, 2,104; hill in center, 1,950; the high hill on west edge, 1,400, while Poestenkill is not over 500, and tide water is only 6 miles west (see general section). In this general descent the plateau participates, its eastern edge ranging from 1,600 to 2,000 feet, and its western from 1,000 to 1,400. A noticeable feature in both the Greylock and Taconic masses is that their western slopes are much longer than their eastern.

The agricultural character of these three belts is almost as diverse

FIG. 19.—Sketch of the profile of the western edge of the plateau in Brunswick, looking south across the Quackenkill.

as their topography. The plateau was once thickly timbered, but its deforestation has left a rocky region thickly strewn with bowlders, poorly supplied with water, badly drained in places, and with little good soil, offering in these respects a marked contrast to the fertility of the Hudson valley and of the Berkshire and Berlin valleys, while the Taconic hills are better watered and drained and their rocks afford more soil than those of the plateau.

AREAL AND PETROGRAPHICAL GEOLOGY AND PALEONTOLOGY.

LITERATURE.

The principal literature on the region is as follows:

Chester Dewey: Geological section from the Taconick range in Williamstown to the city of Troy on the Hudson. Am. Jonr. Sci., I. ser., vol. II, 1820, p. 246.

Amos Eaton: A geological and agricultural snrvey of Rensselaer county in New York, to which is annexed a geological profile extending from Onondaga Salt springs, across said county, to Williams College in Massachusetts. Taken under the direction of Hon. Stephen Van Rensselaer. Albany, 1822. (A part of this section is reproduced by Walcott in Tenth An. Rept. U. S. Geol. Surv., 1890, p. 525.)

Chester Dewey: A sketch of the geology and mineralogy of the western part of Massachusetts and of a small part of the adjoining states. Am. Jonr. Sci., I ser., vol. VIII, 1824. p. 1.

Amos Eaton: A geological nomenclatnre for North Amcrica fonnded npon geological surveys, taken under the direction of the Hon. Stephen Van Rensselaer, prepared for Rensselaerean schools. Albany, 1828. (Includes a "geological profile extending from the Atlantic to Lake Erie rnnning near the 43d degree north latitude and embracing 9 degrees of longitnde. Taken 1822–3; corrected by a resnrvey Febrnary 1, 1828. Amos Eaton.")

Amos Eaton: Geological text book, prepared for popnlar lectures on North American geology, with application to agriculture and the arts. (With a geological map of New York state.) First edition. Albany, 1830. (A second edition appeared a little later.)

Henry D. and W. B. Rogers: Observations on the geological structnre of Berkshire, Massachnsetts, and the neighboring parts of New York, made in Angnst, 1840. Read Jannary 1, 1841. Proceedings of the American Philosophical Society, vol. II, Phila., 1844, p. 3.

Ebenezer Emmons: Geology of New York, part II, comprising the snrvey of the second geological district. Nat. Hist. of N. Y., part IV. Albany, 1842.

William W. Mather: Geology of New York, part I, comprising the geology of the first geological district. Nat. Hist. of N. Y., part IV. Albany, 1843.

Henry D. Rogers: Address delivered at the meeting of the Association of American Geologists and Naturalists held in Washington, May, 1844. Am. Jonr. Sci., I ser., vol. XLVII, October, 1844, pp. 150–152.

Ebenezer Emmons: Agricnltnre of New York, comprising an account of the classification, composition, and distribntion of the soils and rocks, etc. Vol. I, Nat. Hist. of N. Y., part V. Albany, 1846.

W. E. Logan and James Hall: Geological map of Canada and adjacent regions, including parts of other British provinces and of the United States. The geology of the United States, compiled under the authority of Prof. James Hall, in 1864. Geological Survey of Canada, 1865. (The same map on larger scale was published in 1867.)

James D. Dana: On the Hudson river age of the Taconic schists, and on the dependent relations of the Dutchess connty and western Connecticnt limestone belts. Am. Jour. Sci., III ser., vol. XVII, 1879, p. 375.

S. W. Ford: On the western limits of the Taconic system. Am. Jonr. Sci., III ser., vol. XIX, 1880, p. 225.

James D. Dana: Geological age of the Taconic system, with a geological sketch map of the Taconic range. Qnarterly Journal of the Geological Society of London vol. XXXVIII, 1882, p. 397.

James D. Dana: On Taconic rocks and stratigraphy, with a geological map of the Taconic region (including parts of Rensselaer and Colnmbia connties, N. Y.). Am. Jonr. Sci., III ser., vol. XXIX, 1885, pp. 285, 438; vol. XXXIII, 1887, p. 270.

S. W. Ford and W. B. Dwight: Preliminary report upon fossils obtained in 1885 from metamorphic limestones of the Taconic series of Emmons, at Canaan, N. Y. Am. Jour. Sci., III ser., vol. XXXI, 1886, p. 248.

James D. Dana: On Lower Silurian fossils from a limestone of the original Taconic of Emmons. Am. Jour. Sci., III ser., vol. XXXI, 1886, p. 241.

I. P. Bishop: On certain fossiliferous limestones of Columbia county, N. Y., and their relation to the Hudson river shales and the Taconic system. Am. Jour. Sci., III ser., vol. XXXII, 1886, p. 438.

C. D. Walcott: The Taconic system of Emmons and the use of the name Taconic in geologic nomenclature (with a geological map of portions of eastern New York, western Vermont and Massachussetts, and northwestern Connecticut, compiled under the supervision of C. D. Walcott; also a geological section from the Hoosac range to the Hudson river). Am. Jour. Sci., III ser., vol. XXXV, 1888, pp. 229, 307, 327.

I. P. Bishop: A new locality of Lower Silurian fossils in the limestones of Columbia county, N. Y. (Pulvers station, near Philmont). Am. Jour. Sci., III ser., vol. XXXIX, January, 1890, p. 69.

James P. Kimball: Siderite basins of the Hudson river epoch. Am. Jour. Sci., vol. XL, August, 1890, p. 155.

COWORKERS AND ASSISTANT.

The field-work was done mainly in 1890, but part in 1887, 1888, and 1891.

Mr. W. H. Hobbs, in 1887, studied the southeastern part of the town of Petersburg, New York, and I have utilized his maps, notes, and specimens for that area; and have also incorporated in the map the areal geology of a strip of Massachusetts along the Vermont border done by him the same year.

Mr. Aug. F. Foerste revisited with me several localities and found fossils which have determined the age of some of the limestone areas and of the pebbles of the Ashley hill conglomerate in Chatham.

Mr. Charles D. Walcott made all the paleontological determinations, and fixed the age of the bedded limestone of Ashley hill by finding fossils.

Mr. J. E. Wolff studied, microscopically, all the rock specimens collected in the course of the work, and his determinations and descriptions have been used throughout.

Mr. George W. Metcalfe assisted me in the field during the greater part of the summer of 1890.

THE STOCKBRIDGE LIMESTONE.

The lowest horizon in the area above outlined is the Stockbridge limestone (CSs on Pl. XLVI) which occupies the valleys on both sides of the Taconic range. That on the west is Emmons's "Sparry limestone." The limestone varies considerably, being more or less crystalline and ranging from a pure white to bluish gray. West of the Taconic range it is generally grayish, and, as far as observed, never as coarsely crystalline or micaceous as some of that on the east side of Mount Greylock. Veins and nodules of calcite and quartz are common. In consequence of minor folds the limestone forms long, narrow belts on

either side of the Berlin valley. In that on the east side, about a mile south of South Berlin (loc. 2, map), Mr. Walcott found Trenton fossils,[1] and the limestone of this belt and of the Berlin valley is, in all probability, continuous with that of Canaan, New York, where (loc. 3) Prof. W. B. Dwight found the fossils described by Mr. Ford and himself as of Trenton age.[2] In 1891 Mr. Walcott found Trenton fossils 2 miles east of Canaan Four Corners (loc. 10). As all of these localities occur in the *uppermost* part of the limestone, close to the overlying rock, that portion, at least, of the limestone must be set down as Trenton, but as Chazy and Calciferous fossils occur in the upper part of the same limestone in Vermont, the upper portion of the Stockbridge limestone is regarded by Mr. Walcott, and is now generally admitted, as embracing these three divisions of the Lower Silurian. More recent investigations in Vermont have shown, however, that at least 470 feet of the lower part of the Stockbridge limestone are of Cambrian age.[3]

In the limestone area about Petersburg and Hoosick, which is continuous with that of the Vermont and Berkshire valley, Mr. Walcott found several Trenton Chazy fossil localities in 1887 (loc. 6–9). About three-fourths of a mile south of Hoosick Corners, between the two railroads and near the river (loc. 29), the writer found in the limestone good specimens of *Lichophycus ottawaensis*, Billings, which occurs in the Trenton in Canada.[4]

The connection between the limestone areas on both sides of the Taconic range, through the cut at Hancock, is probable from the depth of the cut and the height of the limestone outcrops south of Hancock village and west of the range; but the connection can be shown to be still more probable at State Line (see map), where the Stockbridge limestone of Massachusetts extends over into New York, cropping out about one-fourth of a mile southwest of the railroad station and 170 feet above it, and does not appear to be cut off from the nearest outcrop of the Lebanon valley limestone, which occurs 150 feet lower and a half mile northwest of the station.

At Taplins pond, in the southwest part of Stephentown on the Shillinger farm, there is an outcrop of dark and light gray quartzose limestone, in which Mr. Foerste found an Orthis (loc. 520). Mr. Wolff describes a slide of the light quartzose:

> The scattered grains of quartz and feldspar are numerous, and we have a rock composed of undoubted clastic grains of quartz (one has a prism of Zircon included, i. e., granitic), plagioclase, orthoclase, microcline, rarely a large, broken piece of muscovite, while the cement is exclusively calcite which has replaced in part the detrital grains.

[1] Op. cit., p. 239.

[2] Op. cit.

[3] J. E. Wolff: On the Lower Cambrian age of the Stockbridge limestone. Bull. of the Geol. Soc. of Am., vol. II, 1891, pp. 331–338. T. Nelson Dale: On the structure and age of the Stockbridge limestone in the Vermont valley. Bull. Geol. Soc. Am., vol. III, 1892, p. 514.

[4] Billings. Paleozoic fossils. p. 99, fig. 87, Jan., 1862.

Just west of Taplins pond there is more than one-fourth mile square covered with great fragments or bowlders of limestone which, judging from the absence of limestone outcrops at the north, and from the scarcity of limestone bowlders in the vicinity, probably formed part of underlying or neighboring ledges shattered and now covered with drift. As the Taplins pond limestone outcrop strikes and dips in the same direction as the rock of the ridge north of it, and the strikes are parallel with the Kinderhook valley, and as there are indications about Garfield of the anticlinal structure of this valley, the Taplins pond limestone area has been represented on the map as possibly continuous with that of the Berlin-Stephentown valley.

The limestone outcrops of the main valley stop on the north at Berlin, but as the valley beyond this is covered with drift the limestone may extend farther, but is certainly cut off by schist a mile south of South Petersburg.

THE BERKSHIRE SCHIST.

Lying conformably upon the Stockbridge limestone, but varying much petrographically, is the Berkshire schist (Sb), entirely of Silurian age. On East and Potter mountains, and throughout the greater part of the western arm of the Taconic range, it is generally greenish or grayish, often has a fine micaceous aspect, is saponaceous to the touch, and in some places contains cubes of pyrite. This rock often runs into or is interbedded with a purplish schist of similar character. Both are often traversed by veins of milky quartz and chlorite, and the quartz is occasionally crystallized, which is very rarely the case on the Greylock mass.[1]

The following description embodies the results of Mr. Wolff's microscopic study of nine typical specimens of the greenish and gray schists

[1] Geologists have probably often observed in the schist hills of Berkshire and Rensselaer counties, as well as elsewhere, the peculiar cellular structure which quartz vein matter sometimes assumes, often resembling that of tabulate corals. (See Pl. C.) In some places these "cells" are filled with a brown earthy mineral. In McMaster hollow, on the west side of the Taconic range, small masses of siderite (ferrous carbonate) occur in the quartz veins, partially decomposed to a brownish earthy mineral and traversed by a network of minute quartz laminæ, and also in small columnar masses alternating with quartz. Mr. Wolff examined longitudinal and vertical sections of the cellular quartz with the brown earthy mineral and found that the columns or irregular cylinders of quartz are homogeneous masses, crystallographically a unit, but that they show evidences of crushing or straining, and the brown mineral he determined as limonite. From these data and other field observations it seems probable that this cellular vein matter is formed in the following way:

A. The cleavage foliation of the schist is traversed by joints or fissures, due to contraction or flexure and stretching.

B. These openings are filled by segregation with quartz and siderite which have crystallized in fibrous or columnar forms across the fissures.

C. A further compressure or stretching of the schist has strained the quartz columns and ruptured the siderite columns, thus permitting further infiltration of quartz, forming tabulæ across the columns.

D. The siderite is altered to limonite ($FeCO_3$ to $H_6Fe_4O_9$).

E. The limonite is dissolved and removed, leaving the quartz columns and the cylindrical cavities crossed by quartz tabulæ in the places of the siderite columns. (See Pl. C.) In some cases these cellular quartz veins occur in the stratification planes, and sometimes the quartz columns are curved.

taken from different points on East mountain and on the Taconic range between Petersburg and Hancock:

Principally interlacing fibers of muscovite and chlorite, generally with small quartz grains between their meshes, and an immense number of minute rutile (TiO_2) needles, sometimes plates of ottrelite; magnetite often decomposed to limonite; some tourmaline.

A purplish schist (phyllite) like that of the Taconic range, but taken from the west side of the Berlin valley about 1 mile southwest of Berlin village, is—

Composed of little flakes of muscovite and chlorite, with fibrous sericitic structure in light and dark bands, the latter due to large amounts of black or brownish-black substance in little specks or masses, iron (perhaps manganese) ore, which are mingled with the mica. There are occasional large plates of chlorite and small grains of quartz and feldspar.

In the deep cut between East and Potter mountains the muscovite and chlorite schist is "filled with porphyritic crystals of albite in single twins of round shape, around which the muscovite bends, and rutile fills the feldspar in waving bands."[1]

At the north end of East mountain some small layers in the schist "contain clastic grains of quartz, which show signs of great pressure."

Similarly, in a very quartzose coarse schist from the east foot of the Taconic range, about 2 miles north of Hancock village, "the meshes of muscovite and chlorite embrace masses of aggregate quartz, which are elongated in the direction parallel to the fibers and seem to have been completely recrystallized."

Ten miles south-southwest of Hancock, on the New York line (loc. 324, map), on the southwest spur of Perry peak, these muscovite, chlorite, and quartz schists of the Taconic range, plicated and inclined 90°, are interbedded with several strata, one of them 10 feet thick, of a coarse grit, with blue quartz pebbles about one-tenth of an inch in diameter.

The pebbles are predominatingly quartz, but some, plagioclase and orthoclase feldspar. The cement is a fine-grained aggregate of quartz and feldspar grains with little flakes of muscovite, quartz, and chlorite. The rock has been greatly crushed or stretched, and all these large grains show the effects by breaking up around their border into a mosaic of comminuted material, besides showing evidence through their mass of intense strain. A large part, or the larger part, of the cement has thus been derived from the crushing of the pebbles. The muscovite and chlorite is chemically formed. There are detrital fragments of tourmaline and a little calcite in the cement.

Small clastic feldspar and quartz grains occur also in the Berkshire schist on the west side of Perry peak near Lebanon Shaker village.

Here and there along the western flank and foot of the Taconic range these schists (Emmons's magnesian or Talcose slates, Dana's hydromica schists) pass imperceptibly into dark gray slates, phyllites. These recur and predominate on the west side of the Berlin-Lebanon valley;

[1] See T. Nelson Dale: The Greylock Synclinorium. Am. Geologist, vol. VIII, 1891, p. 1. Albitic schists are very characteristic of this horizon on Greylock, but are far less common on the ridges west.

and between Stephentown and Lebanon springs the slate is black, and quarried for roofing. Similar slates were formerly quarried near Hoosick Corners (loc. 1), and contain Hudson River graptolites, *Diplograptus simplex* described by Mather, Emmons, and Hall, 1843–1847, and recently reexamined by Walcott.[1]

A specimen of the typical dark-gray phyllite, with cleavage at right angles to the schistosity, from the west side of the valley near North Stephentown, is composed

of light and dark banded layers—the light layers are composed of little plates of muscovite (sericite), arranged parallel, inclosing in the meshes quartz and feldspar grains—which are part angular, rounded, or irregularly bounded by the mica; little needles of rutile very abundant. The dark layers swarm with these little needles and irregular little masses of black opaque iron ore. The crumpling with development of cleavage along the axes is confined to certain dark layers, stopping short at the boundary.

The black roofing slate from loc. 240 is composed

of a network of muscovite and chlorite plates arranged parallel to the cleavage, with a great amount of black substance (graphite, iron ore) in little dots or masses. There are frequent round or elliptical areas of chlorite or muscovite, often quartz. All these materials arranged parallel to cleavage. No trace of stratification.

The top of Sugarloaf hill, 2 miles southwest of South Petersburg, is a comparatively massive greenish-gray argillite

composed of little rounded grains of quartz and feldspar, part orthoclase, part plagioclase, probably detrital. The space between them filled with minute plates of greenish muscovite and chlorite plates, with numerous rutile needles. There are large rounded plates of chlorite occurring sporadically, often with lamellæ of muscovite, possibly detrital. The clay cement of this rock is now crystallized, but it seems to represent a lower stage of metamorphism than the Taconic range schists.

These variations in the character of the rock can not be said to mark different horizons, for they occur irregularly and several of them in like proximity to the underlying Stockbridge limestone.

South of Berlin village there are several lenticular masses of schist and phyllite folded in the limestone; one of which is over a mile long. Butternut hill, between South Berlin and North Stephentown, is capped by such a mass.

On the west side of the Berlin valley the Berkshire schist area in one place measures but a few hundred feet in width and in entire thickness. Along the western margin of the schist area there is an apparent transition from the schists to the grits, the unaltered clastic grains becoming more and more numerous toward the grit area; and in places there is an interbedding of schist with fine-grained grits, like that described near Perry peak (loc. 324).

The following specimens represent this transition:

From about 1½ miles northwest of Berlin village:

Greenish gray phyllite quartzite (gneissoid) is composed of rounded or irregular grains of quartz and feldspar, largely plagioclase, separated by comparatively small

[1] Am. Jour. of Sci. III ser., vol. XXXV, 1888, p. 240.

amounts of a cement composed of little plates of muscovite and chlorite mixed with little areas of quartz. There is also quartz forming aggregate lenses parallel to the schistosity.

In a similar specimen from Buck rock, 1½ miles west of South Berlin, the micaceous element is much less prominent, and clastic grains of quartz and feldspar, here rarer, preserve their general shape. Abundance of calcite in the cement.

A plicated greenish phyllitic graywacke is from about a mile west of Berlin Center, between the grit and the limestone, and contains quartzose and micaceous layers, the former an aggregate of grains of quartz and flakes of muscovite, the latter muscovite and chlorite plates in fibrous sericitic intergrowth. Both inclose large grains of quartz and feldspar, evidently clastic grains. Considerable calcite in the cement.

Near Babcock pond, on the north side of the plateau, Mr. Walcott noted a small limestone area. It has grit on its south side, schist on the north, and seems to be either a replacement of the upper part of the schist or a protrusion of the underlying Stockbridge limestone.

THE RENSSELAER GRIT.

From the facts just given and the character of the rocks about to be described no absolute petrographical distinction is attached to the terms Berkshire schist and Rensselaer grit.

The upper part of the east side of the plateau, its southeastern, western, and northern faces, and its top, consist of grit or graywacke, a dark green, exceedingly tough, in some places calcareous, generally thick-bedded granular rock, in which the quartz grains are apparent and, upon closer inspection, the feldspar grains. Numerous veins of quartz, and sometimes of epidote, traverse it.[1]

This rock is, however, interbedded with strata of purplish or greenish slate (phyllite), varying in thickness from a few inches to perhaps a hundred feet. A small section, measured south of Bowman pond, in Sandlake, shows, beginning above, fine grit, 5 feet; slate, 8 inches; coarse grit, 15 feet; slate, 1 foot 6 inches; fine grit, 5 feet; slate, 10 feet. About a mile north-northeast of Black pond, in Stephentown, surrounded by grit, is a mass of slate 600 feet in width which belongs either to the grit or the Berkshire schist. There is a considerable area of green phyllite at West Stephentown and of the purple northwest of Black pond. The thin purple phyllite layers along the west edge of the plateau, loc. 202, in Poestenkill, contain minute branching annelid trails or fucoidal impressions. Some dark dull purple slates near Quackenkill, in Brunswick, used in the manufacture of paint, are made up of small angular to rounded grains of clastic quartz, very rare ones of feldspar, some large chlorite and muscovite plates, some of which may be clastic, some

[1] For a very good general description of the grit see:
Chester Dewey. Am. Journ. of Science, Ser. I, Vol. II, p. 247, 1820.
Amos Eaton. Geol. and Agricultural Survey of Rensselaer county, N. Y., p. 20–22, 1822.
Wm. W. Mather. Geology of New York, II District, 1843. Section on Rensselaer county, p. 382–384.

formed in place. The cement is sericite and chlorite mixed, and a brownish red to yellow pigment scattered about in little specks.

The result of Mr. Wolff's study of slides from typical specimens of grit from sixteen localities along the edges and center of the plateau in the towns of Berlin, Stephentown, Nassau, Sandlake, Poestenkill, Grafton, and Brunswick, is as follows for the ground mass of the rock:

It consists of small fragments of quartz, orthoclase, plagioclase, microcline, biotite, chloritized biotite, and garnet, tourmaline, zircon (apatite rarely), magnetite, titanite, ilmenite, epidote. Also, fine flakes of chorite, muscovite formed all or in larger part in situ; in some places secondary quartz sometimes as an enlargement of the detrital quartz grains, secondary calcite; epidote in small grains also formed in situ or mixed with calcite in small veins (loc. 202) replacing the cement and even part of the clastic grains; epidote also in perfect crystals.

One of the finest exposures of the grit is on the west side of Little Bowman pond, in Sandlake township, loc. 191. An abrupt ledge of fine-grained grit 30 to 40 feet high is traversed horizontally by a bed of conglomerate 5 to 10 feet thick. At the top of the ledge is another like bed 4 inches thick, and at the base still another, partially concealed by fragments and soil. (See Fig. 20.)

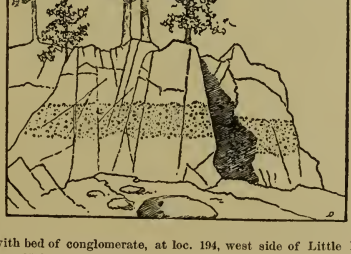


Fig. 20.—Grit ledge with bed of conglomerate, at loc. 194, west side of Little Bowman pond, Sand lake. Height in view, 25 feet. The mass at the right has broken off along a joint plane and slid down. Sketch looking north.

Figs. 1–4 on Pl. C show some hand specimens of this conglomerate. The pebbles of irregular outline measure from two-tenths to eight-tenths inch in diameter, and consist of white, pinkish, or bluish quartz, reddish feldspar, gneiss, slate, and red quartzite, and, as to relative abundance, occur in the order named. Polished surfaces of the rock are attractive owing to the variety of the colors of the pebbles, contrasting with the dark green ground mass. Fig. 21 represents an enlarged section of medium grained grit with a few large pebbles from near loc. 249, near Alps in Nassau, which Mr. Wolff describes thus:

The large pebbles are quartz, like vein quartz, orthoclase and microcline feldspar, *quartzite;* the smaller ones of the same minerals with plagioclase feldspars resembling those in eruptive rocks like gabbro or diorite, fragments of epidote, titanite, garnet, and also one of a basic dike rock (diabase) now largely chloritized, in which, however, the form of the feldspars is still preserved. Also, fragments of magnetite or ilmenite. Cement of calcite formed in situ, of greenish chloritic material, with considerable epidote in little grains either clastic or formed in situ.

A specimen from the high cliff on the west side of the plateau near Pleasant valley, in Brunswick, consists

mainly of quartz and feldspar fragments, the feldspars (orthoclase, microcline, and plagioclase) predominating, with detrital chlorite, muscovite, and biotite plates of comparatively large size and bent. The detrital quartz grains show enlargement; the cement contains smaller clastic quartz and feldspar grains, small plates of green chlorite, aggregates of secondary quartz, calcite and epidote grains, the whole apparently formed in place. The large amount of feldspar in proportion to the quartz and the little cement, together with the enlargement of the quartz, give the rock a very gneissoid appearance.

Another specimen from near loc. 40, Slide mountain, at the extreme northwest corner of the plateau, is composed of detrital microcline, plagioclase, orthoclase, zircon, quartz, quartzite, and two different gneisses.

Fig. 21.—Microscopic section of coarse grit from near Alps, in Nassau, Rensselaer county, showing pebbles of quartz, orthoclase, microcline, and quartzite. The largest pebble is quartzite. The two next largest at upper right hand are vein quartz, enlarged 2 diameters. From a photograph.

West of Black pond, near the line between Stephentown and Nassau, on the Kittles farm, loc. 562, the grit contains several beds of a still coarser conglomerate, none of them over 4 feet thick, two of the coarsest only 1 to 2 feet thick. The groundmass does not differ materially from that of the ordinary grit except in being slightly calcareous. The pebbles are quartz, feldspar, quartzite, slate, limestone, and a coarse white calcareous gneiss. (See Fig. 22.) The limestone pebbles measure from 2 to 4 inches in diameter, but have mostly been dissolved out, giving the rock a spongy appearance. Portions of some remain, however, as projecting points in the cavities. Small slate pebbles are abundant. Most of the larger pebbles are gneiss and measure 2 to 3 inches in diameter, some even more—one $12 \times 8 \times 23$ inches. The gneiss and quartzite pebbles are often fissured.

The following is a résumé of the results of Mr. Wolff's study of sections of the pebbles from these conglomerates.

List and description of the pebbles of the grit.

Quartz: Often blnish, aggregate vein quartz, or homogeneous quartz, pressure-broken before entering into the conglomerate.

Feldspar: Orthoclase; plagioclase; microcline.

Gneiss: Coarse or granitc, consisting of quartz, orthoclase and plagioclase, resembling a binary granite with predominating plagioclase feldspar. (Bowman pond.)

Gneiss: Fine grained, indistinctly banded, composed of grains of blue quartz, orthoclase, plagioelase, microcline, resembling the pre-Cambrian gneiss of the pebbles of the Hoosac range Cambrian conglomerate and similar pre-Cambrian gneisses, occurring in situ in the Green Mountains. (Bowman pond and Slide mountain.)

Gneiss: Granitoid or granite, fine grained, composed of interlocking grains of microcline, plagioclase, orthoclase, and quartz, or a granular aggregate of microcline crystals, inclosing larger orthoclase and plagioclase crystals and masses of quartz. (Black pond.)

Gneiss: Granitoid, white, or granite, fine grained, probably of pre-Cambrian origin, composed of grains of plagioclase feldspar, which predominates, rare grains of orthoclase, considerable quartz, rare flakes of a dirty green mineral, probably decomposed

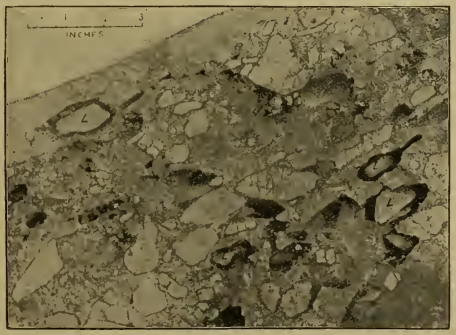


FIG. 22.—Coarse conglomerate with pebbles of limestone, granitoid gneiss, etc., from loc. 562, near Black pond, W. Stephentown. The remnants of six limestone pebbles, marked L, project from their cavities, the rest having been entirely dissolved out. The smallest pebbles are quartz and slate, the larger granitoid gneiss. From a photograph.

biotite, these minerals in granitic arrangement. Secondary calcite occurs in little veinlets and the rock has been exposed to great crushing action, which has faulted the feldspars. In one specimen the rock has more quartz and more orthoclase, and contains prisms of zircon. This is the character of the white gneiss pebbles at loc. 562, near Black pond. The largest pebble found there is composed of crystalloids of feldspar and irregular masses or grains of quartz in granitic structure, the feldspar in large part microcline, but some plagioclase and some orthoclase. The rock seems to be almost free from mica. Some of the quartz grains are shattered by crushing and the feldspars are bent and broken, and secondary calcite has penetrated the cracks thus formed.

Gneiss: Interlocking aggregate of grains of orthoclase, plagioclase, and quartz, with muscovite, biotite, and zircon accessories and secondary calcite in the feldspar (Cambrian or Archæan). Slide mountain, northwest corner of plateau.

Diabase or gabbro: Largely chloritized, in which the form of the triclinic feldspar is still preserved. Alps in Nassau.

Phyllite? Fine grained, of angular pieces of detrital quartz and yellow micaceous cement, a rock less metamorphic than those of the Greylock region or perhaps even of the Taconic range. The cement of detrital quartz and feldspar, epidote, chlorite, and sericite formed in place. Slide mountain, northwest corner of plateau.

Phyllite: Light colored; no section; Black pond.

Phyllite: Black (see description of Grafton specimen below).

Quartzite: Ordinary white, finer grained than average; no feldspar, but little mica. Between loc. 246 and 542.

Quartzite: Red, fine grained, with secondary red iron oxide between the grains. (Bowman pond.)

Quartzite: Black, a fine grained aggregate of round, interlocking quartz grains with large pseudo-porphyritic grains of quartz and orthoclase feldspar and occasional small flakes of mica. Resembles some Cambrian quartzite near Pownal, Vermont. (North part of plateau.)

Limestone: Whitish, of grains of calcite of various sizes, here and there small grains of quartz and feldspar. (Black pond.)

About one-half mile northwest of Mud pond in Grafton (loc. 208) is a bowlder 5 feet in diameter of a dark gray calcareous grit with conspicuous pebbles of a black rock and of quartz and white feldspar. (See Fig. 23.)

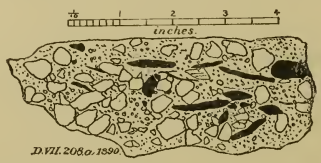


FIG. 23.—Hand specimen of conglomerate with pebbles of black slate, quartz, and microcline. From the northern part of the Great Plateau. From a photograph.

The black pebbles are slate containing angular clastic grains of quartz and feldspar, numerous crystals of magnetite and muscovite or, in one pebble, chlorite. The large quartz pebbles are homogeneous quartz from veins, or coarse gneisses or granites, the large feldspars microcline. In the small fragments of the groundmass plagioclase, microcline and quartz are abundant. The rest of the cement is calcite with a little sericitic material, the calcite encroaching upon or partially replacing some of the feldspar grains. Clastic grains of epidote, zircon, tourmaline, and muscovite here and there.

Specimens of grit from two places along the eastern and southeastern edges of the plateau show the large clastic grains and pebbles, as Mr. Wolff states it, "in process of absorption into the cement," through sericitization.

A metamorphic eruptive, from loc. 51, near the north edge, looking like a mass of reddish slate with epidote and chlorite, Mr. Wolff describes as—

A dull, partly opaque, partly clear material with veins of epidote and rounded cavities filled with chlorite; occasional crystals of sanidine. The rock was originally a spherulitic acid volcanic glass corresponding to the rhyolites or quartz porphyries (spherulitic felsite, pitchstone), due to a surface volcanic flow.

This altered spherulitic felsite is brecciated.

South of Pike hill, near Alps, Nassau (Cole farm), occur a few feet of limestone (St., N., 15 W., Dip. 30° E.), loc. 249. This is

in general a quite pure limestone of rounded or oval grains of calcite arranged parallel and separated by thin layers of graphite or iron oxide. Only here and there little areas contain grains of feldspar mixed with calcite.

The grit crops out 290 feet north-northeast of this, and about the same distance east, and again a short distance west. Fig. 21 is from the range of ledges east.

About 2½ miles south of loc. 249 is Hoag's Corners, beyond which, on the east side of the road, is a north-south hollow with grits on both sides, and the grits also recur west of the road, with a westerly dip. A little more than a mile south of Hoag's Corners and northeast of Tackawasick or Cumming's Pond, in the southern continuation of the same hollow, which here trends N. 25° W., S. 25° E., there is (on the farm of Stephen E. Coonradt) an isolated mass of bluish and light gray limestone. (See loc. 246, map.) It rises perhaps 80 feet above the hollow, strikes N. 20 W., i. e., about with the hollow and with the limestone near Pike hill (249), and dips 50°–55° E., measuring about 70 feet in thickness with some 20 feet of interbedded greenish argillite. Mr. Wolff reports this limestone as resembling that at loc. 249, but with more feldspar, "being composed of grains of crystalline calcite with little specks of black iron oxide and numerous clear grains almost all feldspar (plagioclase) often containing little particles of calcite." About 100 feet from the foot of the limestone knoll on the west side of the hollow is an outcrop of grit with much quartz and little feldspar, striking N. 5 E. and dipping 35°–45° E. and the nearest part of the limestone dips about the same. About 800 feet north of the limestone the typical grits recur with slaty passages, striking N. 5 E. and dipping 70° E. to 90°. Farther north on the east side of the hollow are easterly dipping grits. The nearest outcrop of grit on the ridge east of the limestone is about ½ mile NE. and 250 feet above the hollow, and strikes N. 15 E., dip 55° E. About ¼ mile beyond and 100 feet higher the grit with like dip contains small beds of conglomerate with pebbles of quartzite and gneiss (?), 2 inches in diameter. This ridge continuous with that east of the limestone at Pike hill (loc. 249), and is cut by the Tackawasick creek at Dunham's mills, about 1½ miles north of Coonradt's, where it dips 50°–60° E. The structure as given in Pl. XCIX, Sec. G, and continues to the Black river. The ridge between the limestone hollow and the highway seems to be a compressed synclinal with an anticlinal west of it and another east of it, in the center of which is the limestone. The reddish slate layers associated with the grits of the synclinal contain thin strata of quartzite with casts of fucoids or annelid trails. In the limestone itself Mr. Foerste found, September 9, 1890, the following Trenton fossils: Monticulopora (under old interpretation Lycoperdon), a Murchisonia, a Calymene, an orthis of *O. plicatella*

type, and crinoid stems. As there is no sharp distinction between the fauna of the limestones of the Trenton and Hudson River periods this limestone may belong to either. From the probable structural relations of the limestone and the grit both here and at Pike pond (loc. 249), and their common strike, and again on the west side of Rocky hill on the east of the platcau, and also at Babcock pond on the north, it appears probable that the limestone outcrops of Pike and Tackawasick ponds (locs. 249 and 246) are parts of a narrow limestone belt, anticlinal in structure, underlying the grit and belonging either to the upper part of the Stockbridge limestone, and thus of Trenton age, or else belonging to the Berkshire schist horizon, and then of Hudson river age. Mr. Kimball finds such thin belts of limestone intercalated with argillaceous shales and continuous with calcareous grits overlying conformably the Hudson river shales at Burden, Columbia county.[1] Such strips of limestone also occur at several points in the Berkshire schists, as in the Taconic range west of Pittsfield (loc. 1030), near Perry peak (loc. 323), near White's hill, west of Prospect lake in Egremont, Mass., and on the ridge west of Alford, all belonging either to the Berkshire schist horizon or to the underlying Stockbridge limestone.

THE ASHLEY HILL CAMBRIAN LIMESTONE.

Another limestone belt associated with grits and shales occurs 5 miles SSW. from loc. 246 and due south of Tackawasick pond at Ashley hill, loc. 317, but these belts can not be connected, as they trend differently and are separated by masses of grit. Ashley hill is a low hill in the northeast corner of Chatham township, Columbia county, about a mile north of Rayville or Rider's Mills station, on the Lebanon Springs railroad, and 2 miles south of Brainard in Nassau.[2] The east and west sides of the hill consist of grit or quartzite; that on the east includes some schist or shale. A section of the grit Mr. Wolff describes as—

> A quartzite with occasional feldspar grains, a little micaceous cement, although the grains generally interlock; the original boundaries of the grains often well marked by curved films of iron oxide.
>
> Some of this is calcareous, being identical with above except that the material between the quartz grains is in large part calcareous; enlargement of quartz grains by growth of vein quarts; calcite, probably a secondary replacement of part of the quartzite cement.

Along the upper and west part of the hill is a belt of limestone breccia and conglomerate over 20 feet thick, about 1,500 feet long, striking N. 5° E. to N. 5° W. dipping 45°–55° E. Calcareous quartzite and soft shales are in visible contact with it. The pebbles being limestone, weather easily, while the cement, which is argillaceous or slaty and in places filled with quartz grains, projects on the surface of the rock. The

[1] Op cit. He speaks of the "grits merging into thin bedded limestone."
[2] See Bishop, op. cit., 1886.

pebbles vary from 1 to 4 inches in diameter; one measured 10 by 3½ by 3½ inches. The axes and grain of some of the large pebbles lie at right angles to each other and the grain of adjoining pebbles is often entirely different, but in some places the pebbles are angular and would fit into each other and the cement is calcareous. The rock is thus a breccia but in places a true conglomerate, the pebbles of which, however, have probably travelled no great distance. Many of the pebbles have a pitted surface.

Fig. 24 represents an enlarged section of portions of several pebbles and of the intervening cement. Mr. Wolff describes this slide:

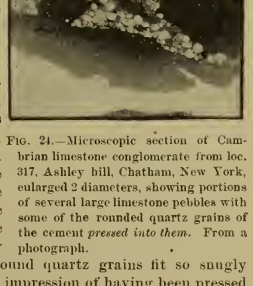


FIG. 24.—Microscopic section of Cambrian limestone conglomerate from loc. 317, Ashley hill, Chatham, New York, enlarged 2 diameters, showing portions of several large limestone pebbles with some of the rounded quartz grains of the cement *pressed into them*. From a photograph.

The clear grains are without exception quartz in generally homogeneous grains of granitic or gneissoid type, i. e., not vein quartz, and of most perfect rounded water-worn shape. Two of the grains are of aggregate quartz in small interlocking areas, like a very fine-grained quartzite. These grains surrounded by coarsely crystallized vein-formed calcite which often shows its formation in situ about the quartz grains by a radical or zonal crystallization. The limestone pebbles are entirely distinct from the calcite formed in situ; they are composed of very small, even-sized grains of calcite without much else—only here and there little clear grains occur of the same size, in part feldspar, in part quartz. Where the large clastic grains come in contact with the limestone there is frequently a thin secondary film of limonite between the two; often the round quartz grains fit so snugly into the limestone that they give one almost the impression of having been pressed into it.

This is an interesting instance of the impression of pebbles by pressure and solution, i. e., by chemical action promoted by pressure, as explained by Sorby and Bishop.[1] Such impressed limestone pebbles in conglomerate are often alluded to in European geological literature.[2] Not only does this explain the fitting in of the rounded quartz grains into the limestone pebbles at Ashley hill, but the finely pitted appearance of the pebbles where the cement has been eroded.

[1] H. C. Sorby: Ueber Kalkstein-Geschiebe mit Eindrücken. Neues Jahrb. für Min., Geol., etc., 1863, p. 80. The figure which he gives of a microscopic section of the Nagelfluhe of St. Gallen, in Switzerland, would answer to illustrate this Ashley hill conglomerate if quartz grains were substituted for his smaller limestone grains or pebbles. See, also, by same author: Proceedings Geol. Soc. Yorkshire, IV, 458–461, describing an experiment with rock salt.

G Bischof: Ungleiches Verhalten schwach wirkender Auflösungsmittel auf Kalksteine. Verhandlungen der Niederrhein. Gesellschaft, Ap. 12, 1855. Also Neues Jahrb. für Min., Geol., etc., 1855, p. 838, where he describes the artificial reproduction of such impressions by weighting grains of quartz resting on a marble slab and pouring on very dilute acid.

[2] Noeggerath: Geschiebe mit Eindrücken von solchen in Konglomeraten. Jahrb. d. geol. Reichsanstalt, 1853, pp. 667–680. See, also, Neues Jahrb. für Min., Geol., etc., 1853, p. 797; 1854, p. 836; 1855, p. 82; 1856, p. 63; 1857, p. 400; 1858, p. 106; 1859, pp. 153, 813; 1861, p. 225. Also J. W. Judd: On the evidence afforded by petrographical research of the occurrence of chemical changes under great pressure. Nature, Vol. 42, p. 103, May 29, 1890. Contejean: Sur les cailloux impressionnés (de Montbéliard). Comptes rendus, Institut de France, pp. 110, 811, 1890.

Mr. Foerste, visiting Ashley hill on September 24, 1890, found some of the limestone pebbles filled with trilobite fragments. He reports:

The unfossiliferous pebbles were white and finer grained. Those containing fossil fragments were darker, grayish white, and appeared coarsely crystalline. If broken open, this appearance is seen at once to be due to innumerable fragments of fossils which lie at all angles and appear on weathered surfaces chiefly as cross sections, mostly 2 to 6 millimeters long and consisting almost entirely of trilobite fragments. They resemble the gray Olenellus Cambrian limestone in the eastern part of Troy.

Mr. Walcott determines the trilobite as Olenellus and finds also opercula of the Pteropod, *Hyolithellus micans*, Billings,[1] and fixes the age of the pebbles as Lower Cambrian, Olenellus fauna.[2]

About a mile south-southwest from loc. 317, bedded limestone crops out (loc. 318), striking with the conglomerate bed of Ashley hill, and having the same quartzite or grit on the west, but with red shales on the east. I revisited this locality with Mr. Walcott in May, 1891, when he found in this limestone a crustacean, *Microdiscus connexus* and a brachiopod, *Linnarsonia sagittalis* var. *taconica*, and thus fixed the age of the beds as upper Lower Cambrian, and to this age must also be assigned the breccia and conglomerate of Ashley hill, as there is little room for doubting their continuity. From recent investigations already referred to,[3] the Ashley hill breccia, conglomerate, and limestone thus belongs to the same horizon as the lower part of the Stockbridge limestone.

Mr. Walcott and myself found bowlders of this Cambrian limestone conglomerate near the west foot of the grit plateau, about 2½ miles north of Poestenkill village, and again several miles farther north, in Brunswick, one measuring 15 by 10 by 6 feet, indicating other outcrops of these Cambrian beds farther north.

The general result of the investigation of the age of the Ashley hill beds may be thus expressed: There is either a fault between the Ashley hill Cambrian beds and the Berkshire schist mass of New Lebanon, bringing the upper Lower Cambrian to the level of the upper Lower Silurian, or else, as suggested by Mr. Walcott, the Silurian portion of the Stockbridge limestone is here replaced by schists which are vertically continuous with the Berkshire schist. In the Taconic region replacement of schist by limestone occurs, as well as the reverse.

The grit recurs at loc. 315, a mile north of old Chatham, on the railroad, associated with red and green shales. This grit corresponds petrographically to the typical grit of the plateau and differs from that of Ashley hill. Mr. Wolff describes it as

containing pebbles of homogeneous quartz, some of aggregate quartz, large plagioclase pebbles decomposed to calcite; the finer portion of the rock composed

[1] See C. D. Walcott: The fauna of the Lower Cambrian or Olenellus Zone. Tenth Ann. Rep. of the U. S. Geol. Survey, 1888-'89, p. 624, and pl. 79, Fig. 1c-1e.

[2] Mather, op. cit., p. 406, regarded the pebbles of these Columbia county limestone conglomerates as of Trenton or Calciferous age. He describes the conglomerate as 20 to 40 feet thick, overlaid by slate and calcareous grit and the cement as slaty.

[3] See Wolff & Dale, op. cit., p. 309.

of fragments of plagioclase, orthoclase, quartz, magnetite, and cement of greenish flakes of muscovite and chlorite; microcline absent.

THE HUDSON RIVER SHALE.

Along the west foot of the grit plateau in Sandlake, Poestenkill, Brunswick, and on the northwest, in Pittstown, is an area of shales and slates. The grits terminate more or less abruptly with the plateau, but the interbedded and underlying purple and green slates continue and pass into soft red, green, or gray shales, with occasional small layers of quartzite. In Sandlake the change from the plateau to the valley may be described as simply a passage from a preponderance of the grits to a preponderance of the interbedded slates and shales.

Associated with the red and green shales occur here and there black shales with Hudson River graptolites, or small beds of limestone with Trenton or Hudson River brachiopods. Thus at 327, a mile north of Chatham, on the Lebanon Springs railroad, one of Mr. Bishop's localities,[1] Mr. Foerste reports finding "in the limestone, in contact with green shales *Leptæna sericea*, a fragment of a strophomenoid shell, crinoid stems, a Murchisonia and Pleurotomaria, a pygidium of a trilobite, and the other fossils mentioned by Bishop." In the Black Rock cut, loc. 329, a mile farther north, the black ferruginous limestone and shale contains Hudson River graptolites. At the north end of the cut these shales pass into red and green shales. The association of such shales with the typical grit a few miles farther north, loc. 315, was alluded to on page 314. Again, at loc. 27, about 2 miles northwest of Pittstown Corners, Mr. Walcott found Hudson River graptolites in black shales adjoining the red shales. In passing around the north end of the plateau, from Hoosick Corners through Potter hill and Boyntonville to Pittstown Corners, or from Hoosick Falls to the graptolite locality (loc. 27), the gradual transition from the schists and slates of Hoosick to the shales of the Hudson valley can be observed. The Hudson river age of the Hoosick slates has long been known (see loc. 1 and 303), and the transition from the Taconic schists to the black slate is pointed out, on p. 304. For these reasons the Hudson river shales and the Berkshire schist are regarded as equivalent terms, but representing masses under different degrees of metamorphism which at certain points pass into each other.

At loc. 213, about 1½ miles north-northeast of Poestenkill village, a small brook rising along the foot of the plateau cuts the reddish and greenish shales, flowing for a distance northerly along the strike, (dip 55° E.). The shales contain many small beds of quartzite, 1 to 3 inches thick, composed of "an even-grained interlocking aggregate of quartz and feldspar grains (secondary enlargement of quartz), detrital grains of zircon, magnetite, with a little chlorite and calcite formed in situ." The under sides of these quartzite layers bear nu-

[1] Bishop, op. cit., 1886.

merous reliefs of trails or fucoids, varying from ¼ inch to 3 inches in thickness, sometimes 2 feet long, often branching or with enlarged extremities. Some are simple spherical nodules.[1] The smaller of these objects, as well as the rock itself, is identical with those adjoining the Trenton or Hudson river fossiliferous limestone near Tackawasick pond, loc. 246 (see page 311). But as such fossils are not exclusively characteristic of any one period of the Paleozoic, they are not further described here.[2]

AREAL GEOLOGY—RÉSUMÉ.

The region covered by this paper includes thus a very irregular ramifying area of the Stockbridge limestone, generally occupying the valley floors in the Berkshire hill country and the adjoining strip of New York state. Intermingled with this is an equally complex area of the Berkshire schists (phyllite and muscovite chlorite schist) forming the Taconic range, East and Potter mountains, and the west side of the Berlin-Lebanon valley and the greater part of Hoosick and Petersburg.

West of this lies the somewhat quadrangular area of the Rensselaer grit covering about 175 square miles, forming the plateau country. It is noticeable that the grit area comes very near the Stockbridge limestone area at several points. Such irregular areal relations point to unconformity. Finally the Hudson river shales border the grit plateau on the west in the Hudson valley, and on the north merge into the Berkshire schist, with which they are approximately synchronous. In Columbia county, however, Lower Cambrian limestones are brought, possibly by faulting, to the level of a mass of schists on the east which is continuous with the Berkshire schist, if not belonging to it.

STRUCTURAL AND HISTORICAL GEOLOGY.

EAST AND POTTER MOUNTAINS.

These mountains form a connecting link between the Greylock mass and the Taconic range proper. The open synclinal structure of East mountain has been shown.[3] No cross section of the Potter mountain mass was attempted. The easterly dip of its western side is well marked at several points, and there is clearly an overturn near the limestone along its eastern foot, but the central crest is evidently much compressed and very complex. There are northwest to southeast strikes

[1] See J. W. Dawson on burrows or tracks of invertebrate animals in Paleozoic rocks and other markings. Quarterly Journ. Geol. Soc., vol. XLVI, No. 184, Nov., 1890, p. 595.

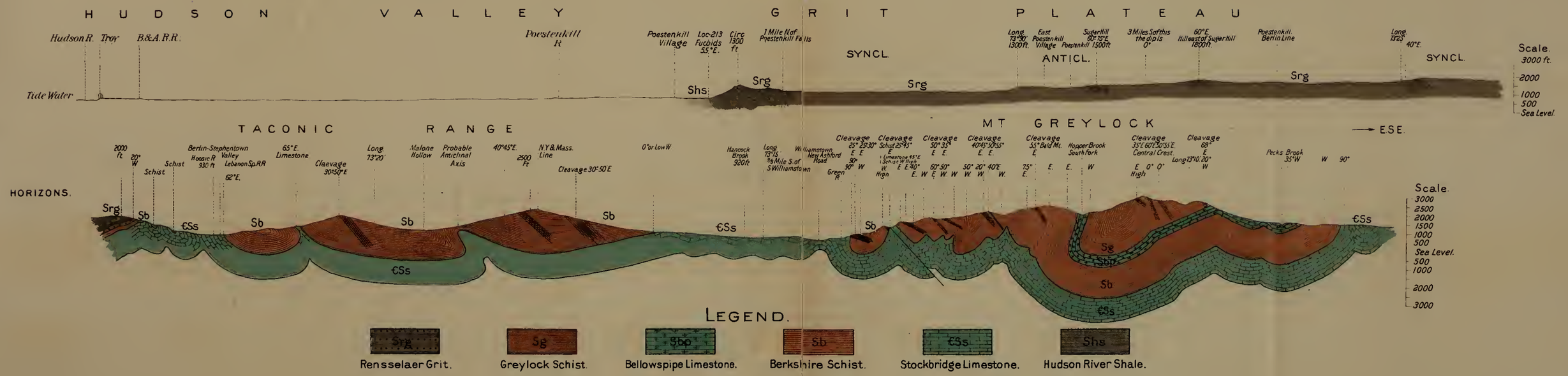
[2] Mr. Foerste, after revisiting the locality with me, suggests "that as these fossils occur as reliefs on the underside of the quartzite layers the actual impressions belong to the surface of the shale layer just beneath, which, however, have been effaced by cleavage. If the impressions were of vegetable origin there must have been an impression in the sand layer, now quartzite, and the cast could only be formed by the decay of the vegetable material and filling in by sandy material. It is evident that the layers are not overturned, because the casts would otherwise be on the upper surface of the quartzite layers."

[3] See Dale: The Areal and Structural Geology of Mount Greylock, section L in Monograph XXIII, U. S. Geol. Survey, abstract of same in American Geologist, July, 1891, entitled the Greylock synclinorium.

GENERAL SECTION. RENSSELAER PLATEAU, TACONIC RANGE & MT. GREYLOCK,

From the East Foot of the Greylock, Mass., to the Hudson Valley at Poestenkill.

Natural Scale, 62.50 = 1 inch = 1 mile.



LEGEND.

Srg	Sg	Sbp	Sb	€Ss	Shs
Rensselaer Grit.	Greylock Schist.	Bellowspipe Limestone.	Berkshire Schist.	Stockbridge Limestone.	Hudson River Shale.

and northerly pitches of 30° near the summits north and south of the Pittsfield Hancock stage road. The East mountain synclinal must continue through the Potter mountain mass, which probably also includes another if not several synclinals, compressed and possibly overturned.

THE TACONIC SYNCLINORIUM.

The principal structural features of the rest of the tract are shown in the general section, Pl. XCVIII, extending from the west foot of the Greylock schist mass (Deer hill) 18 miles to Poestenkill, New York, to which has been added, for convenience of reference, a copy of Greylock section I, of which this section is in fact but the continuation. Both sections together measure 23½ miles. Minor structural features are shown in the six subsections across the Berlin-Lebanon and Kinderhook valleys, Pl. XCIX. The observations upon which the general section is based will now be briefly given.

The presence of a very fine and always easterly dipping cleavage throughout the fine grained schists of this the northern and western arm of the Taconic range obscures its real structure, and accounts for its having been regarded by Emmons as dipping under the limestone on its east side and therefore of different age from the schists of Mount Greylock (the eastern arm of the Taconic range) and therefore called "Second Magnesian slate."[1] But Eaton's section of 1822 shows the easterly cleavage distinctly. The Professors Rogers in 1841 earnestly contended that these schist masses represented numerous closely folded inclined anticlinal and synclinal axes.[2] After a careful study of the greater part of the schist areas of Berkshire county, the first inference one would draw from the uniform easterly dip on the Taconic range would be that it consisted of one or several compressed and westerly overturned folds; but there are indications that the dip is not uniformly east. Thus in a small brook near and north of Hancock village (loc. 926) the schist has three foliations: I. Striking N. 25° to 40° E., dipping 40° to 55° SE. II. Striking N. 25° E., dipping 70° ESE. III. Striking N. 35° to 40° E., dipping nearly 0°. Of these II is close-joint cleavage, and one of the others stratification, and the other Ausweichungs-clivage.[3]

At a point about 1½ miles west of South Williamstown, in the first hollow north of Mill's hollow and about 1,000 feet west of the limestone-schist boundary, the easterly cleavage foliation of the schist is crossed by plicated stratification foliation dipping low west or 0°.

Near the road angle about 1½ miles southeast of the top of Berlin mountain close to the limestone-schist boundary, the limestone dips at low angle west or 0°, and 50 feet vertically above this the schist has a

[1] See Geol. 2d District, p. 145, Sec. 46.

[2] Op. cit.

[3] As to what the signs of stratification are in the Taconic schists, see Greylock report and abstract of same, cited on p. 314. Ausweichungs-clivage corresponds to slip cleavage, but is more accurate.

minutely plicated horizontal stratification foliation. Again about a mile west of this point, i. e., about halfway up Berlin mountain, while the schist has a well marked cleavage dip of 35° E. without a trace of any other foliation, Mr. Wolff finds that under the microscope this easterly foliation is crossed "nearly at right angles by a minor fibrous structure caused by fibers of muscovite, generally in clear rectangular form, which cut across the other fibers," which is very probably a remnant of a westerly dipping stratification-foliation.

Mr. W. H. Hobbs found (in 1887) farther north, about 1¾ miles west of Williamstown, on the south side of Buxton brook, a cleavage-foliation dipping about 20° E. across a perfectly distinct, somewhat coarsely plicated, stratification foliation dipping west at a high angle. He also reports high westerly dips at two points about 1½ and 2 miles south of this locality. From these indications the Stockbridge limestone is regarded as passing under the eastern foot of the Taconic range with a low west dip or horizontally.

On the west flank of Berlin mountain east of Barber and McMaster hollows the stratification undoubtedly dips 35° to 45° E., but just west of this—north and south of section—there are indications of westerly stratification dip. Thus, in a steep ravine about 2 miles east of South Berlin traces of a plicated stratification dip W. or SW. across the easterly cleavage. Near the end of McMaster hollow about 3 miles east of Berlin village three foliations occur: I. Strike N. 3° to 30° E., dip 40° E. II. Strike E. to W., dip S. III. Dip NW. or N.

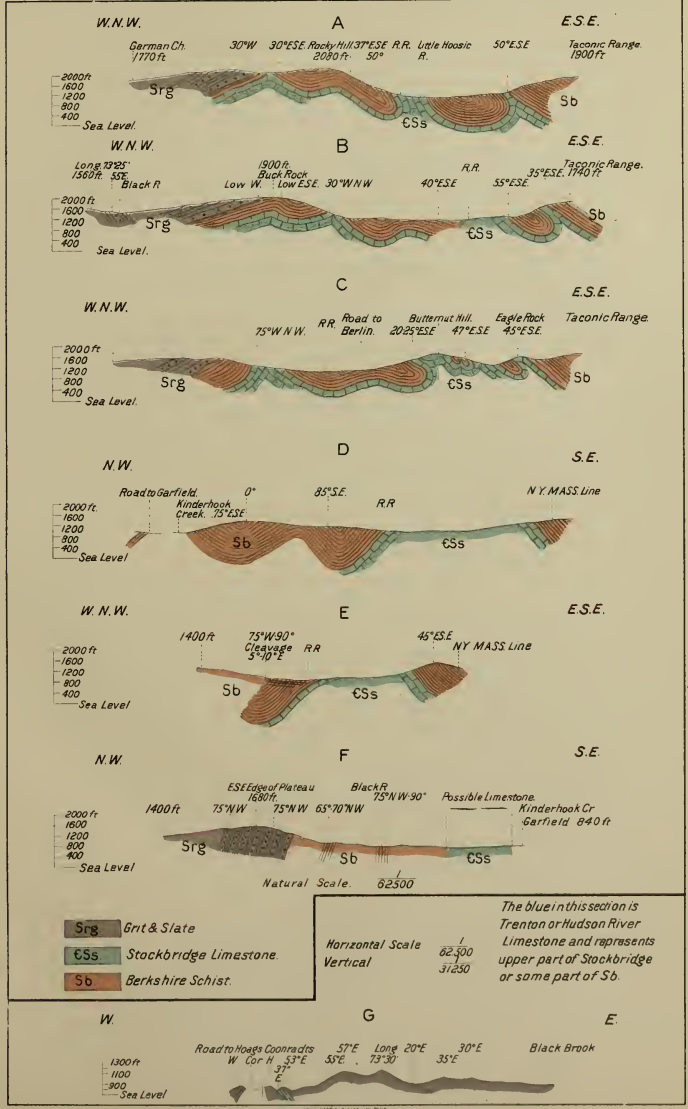
Of these I and II are cleavage, while III is stratification. On the Williamstown-Berlin road, about 1½ miles west of the New York-Massachusetts line, there are indications of horizontal or gently undulating stratification.

Mr. Hobbs in 1887 found high west and high east dips forming a small anticline at a point but little north of the north limit of the Berlin sheet and about 1½ miles east of South Petersburg, which locality would be about in the line of the strike of the two localities just described.

These facts taken together indicate the probable presence of at least one anticlinal axis running through the middle of the Taconic mass.

Farther west about a mile east of the Berlin valley is an undoubted anticline overturned to the west as shown by the narrow strip of limestone with well observed contacts and easterly dips on either side. This limestone strip is continuous with the large area of Stockbridge limestone, which along the west foot of the range, between Stephentown and North Stephentown, occurs in frequent contact with and dips east under the Taconic schists. Furthermore this limestone strip strikes with an anticlinal axis, of which Mr. Hobbs found traces in the township of Petersburg, almost 2 miles west of the New York line along the boundary between "school districts" 4 and 5.

Therefore it is not pressing the facts too far to assume that at least



SUBSECTIONS ACROSS EASTERN & WESTERN EDGES OF RENSSELAER PLATEAU.

two anticlinal axes traverse this arm of the Taconic range, as shown in the general section. The relations of the limestone of the Berlin valley to the Taconic schists on the east have never presented any difficulty, as their contact and easterly dip can be easily observed both at Berlin and farther south, as stated above.

THE BERLIN-LEBANON ANTICLINAL VALLEY.

The somewhat complex relations of the Stockbridge limestone of this valley to the rocks on the west are shown in the six subsections. The observed dips are separately indicated. A section constructed through the steep slate mass on the west side of the valley a half mile north of South Berlin, i. e., between subsections A and B, would show northwest dips on the east flank of that mass, followed west by southeast dips, and east dips on both sides of the narrow limestone anticline on the east flank of the Taconic range. The eastern half of the western slate mass would be an open syncline, and the valley at this point would correspond to a normal anticline. The subsection and map show the apparent thinning out of the "Berkshire schists" on the west side of the valley, and the apparently conformable deposition of the grits upon them, and the more or less complex anticlinal structure of the Berlin-Lebanon valley.

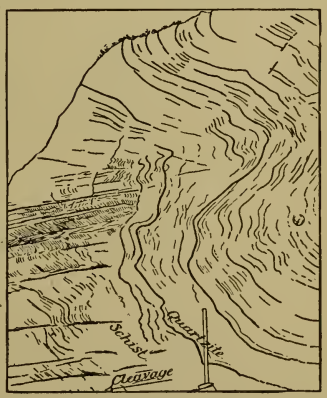


FIG. 25.—Nearly horizontal cleavage-foliation in mica schist now in vertical folds. Clarendon, Vermont. From a photograph. The hammer handle is 30 inches long (see p. 320).

The slates at the quarry between Stephentown and Lebanon Springs (loc. 240 and subsection E), afford an interesting example of typical slaty cleavage in distinction from slip cleavage, which is the prevalent form of cleavage in the Taconic schists. The rock has been described on page 305 as a black roofing slate in which the axes of the particles have all assumed the direction of the cleavage. The stratification, indicated by coarsely undulating bands on the weathered surface, strikes N. 10° E. and dips in minor folds 90°, or high west. (See Pl. CI.) This is crossed by two cleavage foliations: I. Strike N., dip 7° to 10° E., dominant, quarrymen's "Water-Cleavage." II. Strike N., dip 3° to 5° E., obscure, quarrymen's "Cleavage."

The latter only is utilized in preparing slates for market. There are three systems of joints: I. Strike N. 10° W., dip 90°. II. Strike N. 45° E., dip 90°. III. Strike N. 10° E., dip 30° E.

Veins of quartz mixed with calcite and containing pyrite occur in some of the joint planes.

Assuming from Sorby's, Tyndall's, and Daubrée's experiments that slaty cleavage results from pressure in a direction generally at a considerable angle to the cleavage plane, it is noticeable that the cleavage-foliation here, while preserving its normal parallelism to the axial planes of the folds, crosses the folds in a nearly horizontal direction. This, unless in exceptional circumstances, would imply that it was produced either by the weight of an overlying mass, now eroded, or else, and that more probably, by lateral compression producing highly in-

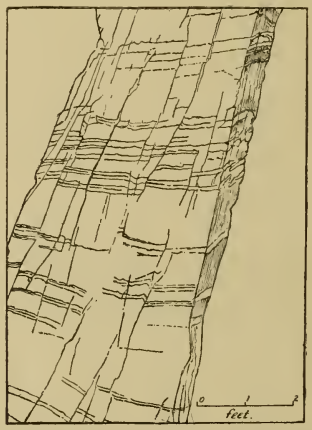


FIG. 26.—Slate slab from the Lebanon Springs quarry, with stratification faulted on the cleavage face, along joint planes, and also on the joint face (right-hand side), along the cleavage plane. Slab nearly horizontal when in situ. From a photograph.

clined or vertical cleavage during or immediately after the formation of the folds and before they were forced into their present vertical position. A clear case of this occurs in Clarendon, Vermont, and is here quite pertinent. (See Fig. 25.) Strata of Cambrian quartzite and mica schist stand erect. The quartzite is in folds about 8 feet across with minor plications 2 feet across, while the adjoining schist is minutely plicated and traversed with a cleavage foliation dipping 10°. This cleavage was evidently formed before the erection of the mass.[1]

Fig. 26 represents a large slab from the Lebanon quarry, horizontal when in situ, showing faulting along the joints of System II, causing

[1]See George F. Becker: Finite homogenous strain, flow and rupture of rocks, Bull. Geol. Society of America, Vol. 4, pp. 13-90, 1893; the gist of which seems to be that the direction of the force which produced the cleavage forms an angle of about 45° with the cleavage plane.

PLATE C.

DESCRIPTION.

FIGS. 1–4. Polished specimens of conglomerate from the Rensselaer Grit at loc. 191, Little Bowman pond, Sandlake, Rensselaer county, New York. Natural size.

FIG. 1. The reddish-brown pebble is quartzite; the largest and the upper central one are gneiss. The cream-colored one and the minute red ones are feldspar; the rest, quartz.

FIG. 2. The large, purplish pebble is quartz; the large one at right is gneiss; the reddish brown, feldspar.

FIG. 3. The rectangular cream-colored and the reddish brown are feldspar; the greenish one is gneiss; the purplish, quartz. A quartz vein at upper left side.

FIG. 4. The upper left and lower left are quartz; the other large ones are gneiss.

1

2

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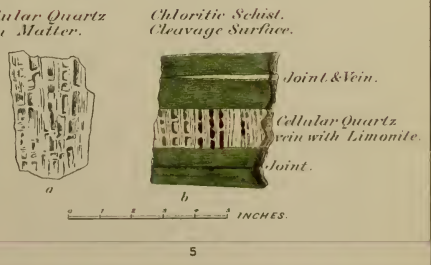

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FIGS 1-4 POLISHED SPECIMENS OF CONGLOMERATE FROM THE RENSSELAER GRIT WITH PEBBLES OF QUARTZ, FELDSPAR, GNEISS AND QUARTZITE.
FIG 5. CELLULAR QUARTZ VEIN MATTER FROM THE SCHIST OF THE TACONIC RANGE

displacement in the stratification bands. The right side of the slab, as well as some of the strata in Pl. CI, show another faulting of the bands along the dominant cleavage system I.[1] All the phenomena at the Lebanon Springs quarry, taken together, indicate extreme pressure operating in several directions and quite possibly at different times, and probably also the rupture of the anticlinal of the valley.[2]

About a mile north of Berlin village, on the east side of the valley, at a small waterfall, quartz veins in coarse plications traverse with a westerly dip the usual easterly dipping cleavage or stratification, or both, which prevail along the east side of that valley. (See Fig. 27.) Although the evidence is not perfect, yet it seems probable that these quartz veins fill cavities formed by the opening and flexure of joints, in consequence of pressure operating on the beds subsequent to the contraction or stretching which produced the joints.

FIG. 27.—Phyllite ledge (Berkshire schist) near Berlin, New York, west foot of Taconic range, with a foliation dipping 45°–50° east, crossed by another, plicated in places and filled with quartz, dipping 35°–45° west.

As the undoubted instance of plicated cleavage recently found at West Rutland, Vermont, in the same range stands in logical connection with this possible plication of joints, it is here described in full.[3] It occurs west of the marble quarries, at the foot of the Taconic range in the Berkshire schist formation—here a very pale greenish sericitic schist. The exposures are on the south sides of vertical east to west joint faces. The direction of the stratification is determined by certain

[1] Comparo an article: A Faulted Slate, by J. J. Harris Teall, Geol. Mag., N. S., Dec. III, vol. I, p. 1. London, January, 1884.

[2] For the recent literature of cleavage, see Report on Mount Greylock, cit. p. 316. For a discussion on the causes of slaty-cleavage, by Alfred Harkey and O. Fisher, see Geol. Mag., Decade III, vol. II, 1885, pp. 15, 174, 246. Also George F. Becker, op. cit. For slaty-cleavage in the Appalachians generally, see Henry D. Rogers, on General Phenomena of slaty-cleavage in the Appalachians, etc., Geol. of Penna., vol. II, part II, New York, 1868, p. 902; and on the Near Approach to Horizontality in slaty-cleavage, ibid., vol. I, p. 247. For this and other cases of slaty-cleavage in Pennsylvania, see R. H. Sanders, The Slate Region, Lehigh and Northampton, Second Geol. Survey of Penna., Harrisburg, Pa., 1883, D. 3, vol. I, p. 95, Pl. I, and pp. 119, 121, 127. Prof. Rogers (op. cit.) describes, vol. II, p. 903, Fig. 715, "A fan-like arrangement of cleavage at an anticlinal axis," which might be explained, as the Lebanon locality has been, by supposing vertical cleavage, to have been produced before the formation of the anticlinal; for a horizontal bed with vertical cleavage would, if flexed into an anticlinal, have its cleavage in fan-like arrangement.

[3] Briefly described by the writer in American Journ. of Science, III ser., vol. XLIII, 1892, p. 317.

beds of calcareous schist or impure limestone 1 to 4 inches thick, which have a horizontal or low westerly dip. (See Figs. 28, 29.)

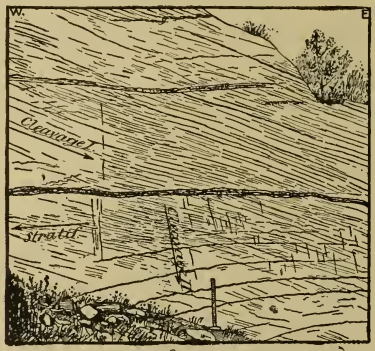


FIG. 28.—South side of a ledge of sericite schist (Berkshire schist) at West Rutland, Vermont, showing nearly horizontal beds of calcareous schist, crossed by one cleavage-foliation dipping 30° east, and another about 80° east. The hammer handle is 30 inches long. From a photograph.

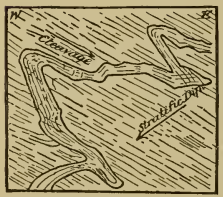
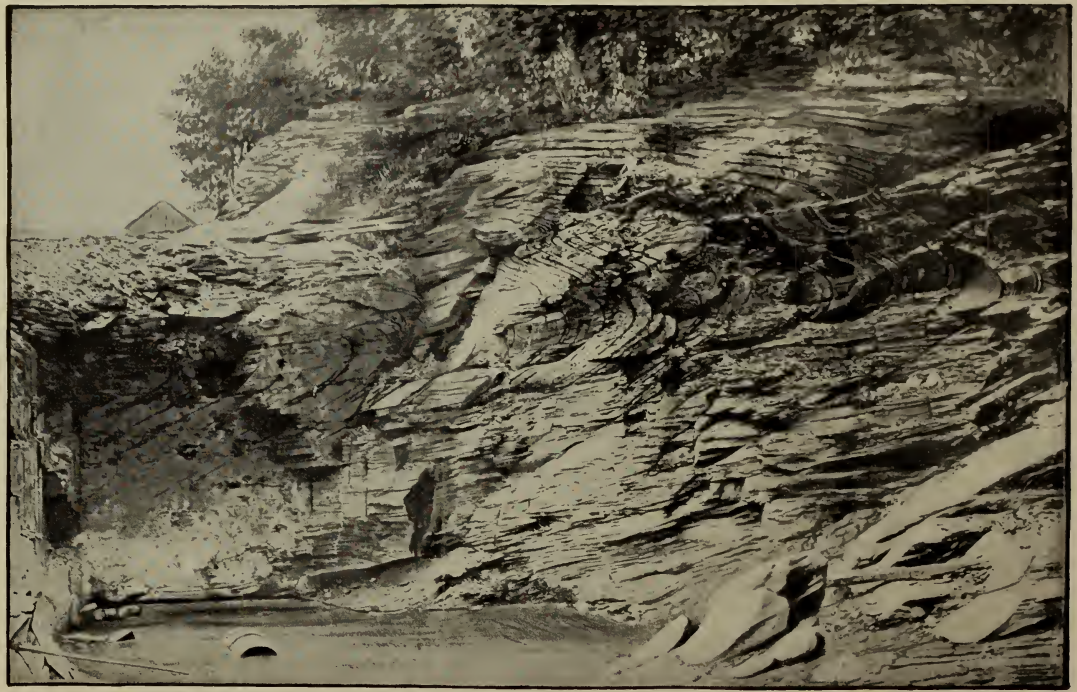


FIG. 29.—South side of a ledge of sericite schist (Berkshire schist) at West Rutland, Vermont, showing a coarsely plicated bed of calcareous schist dipping west, crossed by a cleavage foliation dipping 30° east. The area is 40 inches square. From a photograph.

FIG. 30.—South side of a ledge of sericite schist (Berkshire schist) at West Rutland, Vermont, showing a finely plicated stratification-foliation dipping west, crossed by two cleavage-foliations. I, dipping low east, and II, high east. The area is 32 x 40 inches. The picture is tilted, changing the angles. From a photograph.

Crossing these with an easterly dip of 30° is the dominant cleavage foliation of the Taconic region in Vermont and Massachusetts. Here



GENERAL STRUCTURE AT LEBANON SPRINGS SLATE QUARRY.

and there are indications of a secondary cleavage foliation dipping about 80° east. (Fig. 28.) In one part of the ledge there is a finely plicated foliation parallel to the calcareous beds (see Fig. 30), and here again the secondary cleavage-foliation, II, appears. In portions of the ledge cleavage-foliation I undulates in gentle folds, about 1 inch in diameter, across the calcareous beds. (Fig. 31.)

FIG. 31.—South side of a ledge of sericite schist (Berkshire schist) at West Rutland, Vermont, showing undulations in cleavage-foliation I, crossing an undulating bed of calcareous schist. The area is about 20 inches square. From a photograph.

A microscopic section of one of the sharper folds shows the relations of the two plicated foliations. (Fig. 32.)

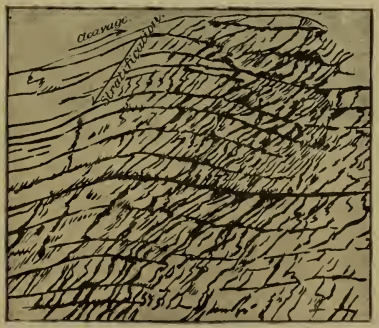


FIG. 32.—Microscopic section of specimen from ledge in Fig. 31, showing the folding of both stratification and cleavage foliations. Area, $\frac{3}{16}$ inch square. From a photograph.

A part of the same section still more enlarged (Fig. 33) shows that this cleavage is Ausweichungs-clivage, and that in places it has exceed-

ingly minute plications.[1] The prominence of the cleavage planes in both Figs. 32 and 33 is partly due to the infiltration of ferruginous matter. Between 40 and 50 cleavage planes of each set are visible in hand specimens. The steps in the process of the formation of the rock structure at West Rutland seem to have been: First, plication of the beds; second, resultant cleavage-foliation I (Ausweichungs-clivage); third, plication of cleavage-foliation I by pressure in the direction of the cleavage dip; fourth, resultant cleavage-foliation II (Ausweichungs-clivage) passing into close-joint cleavage.

FIG. 33.—Part of section of sericite schist in Fig. 31 under greater enlargement. Area, $\frac{1}{16}$ inch square, showing minute plications in cleavage-foliation I. From a photograph.

THE GRIT SYNCLINORIAL PLATEAU.

There is a gradual bending around of the strike of the grit along the east and southeast edges of the mass from north-south to northeast-southwest and to east-west, and the underlying Berkshire schists follow in close parallelism. A corresponding bend and parallelism occur at the northwest edge of the plateau. Between Boyntonville and Potter hill, at the north, the schists have a southerly pitch of 30°. These facts and those shown on the subsections indicate the apparent structural relations between the grits (Srg), schists (Sb), and limestone (CSs).

About 2 miles west of the east edge and near the line of the general section the dip changes to east, and this recurs in the Black River valley 2 miles south of the German church, and also north of Dyking pond, and again at several points in Stephentown. A synclinal, therefore,

[1] See H. Rensch, Bømmelfjen og Kommøn med omgivelser, p. 196, Kristiania, 1888. Also: A. Baltzer. Der mechanische Contact von Gneiss und Kalk im Berner-Oberland. Pl. XIII, Fig. 11. Beitrage zur geologischen Karte der Schweiz. Vol. XX, Bern., 1880.

occurs a little west of the east edge of the plateau, and this seems to continue northward into the schists and slates between Potter hill and the Hoosic river. In the hill south of Grafton center, loc. 207, is an anticline, and at least one anticline occurs also in the slates and shales between Pittstown Corners and Hoosick Falls. Therefore at least one anticline probably runs through the center of the plateau.

Outcrops on the plateau are generally confined to the hilltops or edges; great areas are covered with swamps, and the ponds are numerous. As far as the region could be explored, nothing but grit and its interbedded slate and one eruptive were found.[1] The grit itself is usually so massive and traversed by so many sets of planes that its stratification can only be determined where it incloses small beds of shale or slate. Sometimes this slate has a cleavage distinct from any in the inclosing grit. At one locality only (loc. 191, Bowman pond) were horizontal strata

FIG. 34.—Anticline of grit and slate cut by the Poestenkill at Barberville, west edge of plateau, Poestenkill township. Photograph taken looking south. The hammer handle is 30 inches long.

found, but others probably exist. It is quite probable that several gentle folds occur between the central anticline and the west edge. In the southwest corner conflicting pressures have operated, for near Black pond the strike is N. 5° W.–N. 15° E., dip 20°–35° E.; but near Taplins pond it is N. 40°–70° E., dip 50°–70° N., while between the two the strike is N. 25°–60° W., and dip 40°–70° NE. At the northeast end there are also abrupt changes in the strike.

[1] Bowlders are enormously abundant on the plateau, and these almost all grit, indicating a large amount of erosion in the northern part. The bowlders are so numerous that some of the roads, although nearly level, are well-nigh impassable. The brook beds are full of them. Stone walls 10 feet thick, of bowlders collected to clear the land, are frequent.

The structure of the west edge of the plateau, as shown in the general section, was taken from between Barberville and Poestenkill, at the falls and in the gorge of the Poestenkill, and on Snake hill, loc. 202. The river at Barberville flows south for a space along the west side of a small anticline of grit and purple slate, and then making a sudden easterly turn, cuts through the top of the anticline (Fig. 34), flows into the adjoining syncline and then plunges down some 70 feet, cutting off the east flank of a low anticline, the layers of which dip at a small angle east. (See Figs. 35, 36.) The stream then makes a turn to the west and for over half a mile flows in a gorge at the bottom of a deep incision across the folds of the western edge of the plateau,

FIG. 35.—The head of Poestenkill gorge, from the east, showing the easterly dipping grit strata of the east side of second anticline along the west edge of the plateau, cut by the Poestenkill. From a photograph.

forming a sort of gateway, with Snake hill on the south and a corresponding mass on the north, through which passes off a large part of the drainage of the plateau. A somewhat similar cut in the west edge occurs at Pleasant Valley, East Brunswick, but the stream, Quackenkill, before breaking through the edge runs south for over 2 miles, possibly taking advantage of a ruptured anticline. About 1,000 feet west of Poestenkill falls the grits and slates dip 15° E. and then 70° to 75° W., forming another anticline, which is closely followed by a sharp syncline, possibly accompanied by some faulting. (See Fig. 37.) Low easterly dips continue along the river to a point about half a mile west of Snake hill. On Snake hill the grits and purple slates strike N. 15° E. and

dip 40° to 50° E., corresponding to the west side of one of the synclines in the gorge. The structure of the west edge of the plateau consists therefore plainly of at least two synclines and two anticlines, i. e., of several folds. Such folds have also been shown to exist east of Tackawasick pond (Pl. XCIX, G), and the topography about Quackenkill points to a like structure.

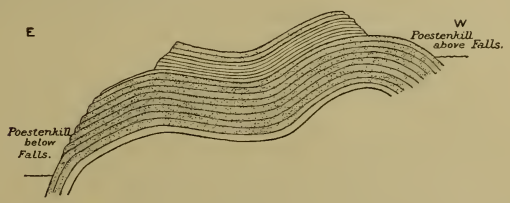


FIG. 36.—Section through the anticlines at Poestenkill falls. Height between water levels, about 100 feet.

The general structure of the plateau consists therefore of a well marked syncline along its east side, a compound syncline along its west side, and certainly one and probably several folds in the intervening area. It is a synclinorium from 6 to 9 miles wide and about 20 miles long, mainly of hard dense rocks with softer rocks underlying it on all sides. This synclinal structure is apparent in its narrower southwest portion. If the fault shown to be possible south of the plateau, p. 314, continues along the foot of its west side it is not great enough to bring up anything older than the Berkshire schist into contact with the grit. A longitudinal section through the plateau from the NNW. to the SSE. would also show a trough structure. See map. There is

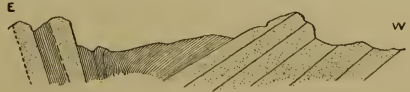


FIG. 37.—Syncline in Poestenkill gorge. Length, 150 feet.

an exceptional E.–W. hollow about 2 miles south of the extreme north end of the plateau corresponding nearly to some of the strikes. On the south side of this hollow, between Babcock pond and Kautsville, loc. 51, in contact with southerly dipping schists, occurs the eruptive rock described by Mr. Wolff as "a surface volcanic flow." This may indicate an E.–W. line of fracture and explain the origin of this peculiar hollow. The area covered by this eruptive is about 500 feet square.

THE HUDSON VALLEY.

Even if a fault, obscured by the similarity of the shales to the slates interbedded with the grit, separates the shales from the grits, the former are still in about their normal inclination, nor, as appears from Mr.

Foerste's interesting inference from the Poestenkill fossils (p. 316, footnote) do they form part of an overturned fold. They dip east as do the nearest outcropping grits east of them, although at a different angle.

THICKNESS OF THE FORMATIONS.

The maximum thickness of the Stockbridge limestone about Mount Greylock was estimated at 1,400 feet,[1] and in the Vermont valley as about the same, the minimum being 1,000.[2] The sections across the Berlin-Lebanon valley indicate an exposed thickness of from 400 to 1,200 feet. The conspicuous limestone knoll northeast of Stephentown in the valley is an open syncline, probably continuing southwards, indicating the probably complex nature of the anticline of the valley between Stephentown and Lebanon. The limestone may therefore not measure any more there than it does further north, i. e., 1,200 feet.

The Berkshire schist on the Taconic range would measure about 2,000 feet if there be not over two anticlinal axes. This does not exceed the maximum figure for Mount Greylock, but liberal deductions are to be made for minute plication, "stauung." However, 2,000 feet is the thickness ascribed to the Hudson river rocks near Quebec,[3] and Mr. Kimball's measurements of the Hudson river beds near Borden in Columbia county, give a total of 1,285 feet.[4] On the west side of the Berlin valley the thickness of the schists runs down to 400 and possibly even to 200 feet. (See the general section and subsections A and B.) This may be accounted for by regarding the grits as having replaced the greater part of the Berkshire schist or else by supposing the schists to have been eroded before the deposition of the grits. There is no stratigraphical evidence of unconformity between them. The unconformity may have been obscured by a later orogenic movement.

The Rensselaer grits can not be accurately measured, owing to the uncertainty as to the number of folds in the central part of the plateau, but there seem to be about 2,000 feet exposed along the southeast edge (see subsection F). West of Black Brook valley there are about 1,400 feet (see Sec. G, Pl. XCIX), and a mile farther northwest of Black pond there are at least 1,200 feet exposed.

As the area of the Hudson river shales was only partially studied no estimates of their thickness were obtained.

THE CONGLOMERATES.

Before giving all the foregoing results in tabular form a discussion of the conglomerates is in place, as it will bring out the general significance of these results. The Ashley hill Cambrian conglomerate is not considered here.

[1] See Greylock report, referred to on p. 316, footnote 3.

[2] See Age and structure of Stockbridge limestone in Vermont valley.

[3] J. D. Dana, Manual of Geology, 3d edit., p. 196.

[4] Op. cit.

The pebbles of the conglomerate in the grit include three groups of rocks: (1) Gneisses or granites; (2) slates (phyllites), quartzites, limestones; (3) diabase or gabbro. Mr. Wolff distinguishes among the gneisses two chief varieties (see p. 309): *A fine grained banded gneiss* (of blue quartz, orthoclase, plagioclase, and microcline) resembling the pre-Cambrian gneiss of the Hoosac mountain Cambrian conglomerates and similar pre-Cambrian gneisses occurring in situ in the Green mountains, and a *white granitoid gneiss* (of quartz, plagioclase, orthoclase, in some specimens also microcline, with or without biotite), probably likewise of pre-Cambrian age. The former is from Little Bowman pond, the latter from Black pond 6 miles farther south. The feldspar and quartz pebbles of Bowman pond he regards as also derived from pre-Cambrian gneisses or granites and the small fragments of tourmaline and garnets from crystalline schists.

The slates of the pebbles may be of Cambrian or Hudson River age, the limestone from the Stockbridge or Hudson River limestone, i. e., Cambrian or Lower Silurian, and the quartzite most probably from the Cambrian.

The general inference, therefore, from the pebbles is that the beds in which they occur were unconformably related to certain pre-Cambrian gneisses and certain slates, limestones, and quartzites of Cambrian or Lower Silurian age.

The nearest pre-Cambrian masses exposed at present are—that west of Lake George, 35 to 40 miles north; that in northwest Connecticut, trending with the highlands,[1] 35 to 40 miles south; that just north of Mount Greylock, in Clarksburg, 22½ miles N. 50° W. from the coarser conglomerate at Black pond (loc. 562) and 20 miles N. 65 W. from the finer at Bowman pond (loc. 191); and finally that on the Hoosac range, about 21 miles east. The Adirondack pre-Cambrian lies 150 miles NNW. Prof. Raphael Pumpelly has shown that before the deposition of the Cambrian the pre-Cambrian granitoid gneisses of Clarksburg, and probably those of Hoosac mountain, had probably been for a long time subjected to atmospheric influences, and that during a portion, at least, of the Cambrian period they were above water.[2] These conglomerates of the grit show that there must have been soon after Hudson River times (i. e., after the close of the Lower Silurian) not only pre-Cambrian, but Cambrian, if not Lower Silurian, rocks above water not very far from the Rensselaer plateau.[3] In other words, that some member of the Silurian is here unconformably related to the pre-Cambrian, the Cambrian, and possibly some of the strata of the Lower Silurian. The unconformity between the grit and the underlying Silurian beds was, in the

[1] Mr. J. P. Kimball, op. cit., referring to the low proportion of alumina in contrast to the large proportion of magnesia in his analyses of the iron ores of the Hudson River beds at Burden in Columbia county, calls attention to the "detrital derivation of the earthy admixtures from basic, notably hornblendic rocks, as prevailing in the Archean highlands."

[2] R. Pumpelly: The Relation of secular rock disintegration to certain transitional crystalline schists. Bull. of the Geol. Soc. of Am., vol. II, pp. 209-225, Rochester, New York, Feb., 1891.

[3] The size of one of the gneiss pebbles at Black pond, 12 by 8 by 3 inches, is noticeable in this connection.

vicinity of the plateau, so slight as to leave no stratigraphical evidence of itself, except that afforded by the pebbles.

Such relations between members of the Siluro-Cambrian series have been shown to exist at no very great distance; thus R. W. Ells describes a conglomerate of Calciferous age near Quebec, with pebbles and bowlders containing fossils of Potsdam age.[1] Sir Wm. Logan found an interruption in the succession of the deposits between the base of the Trenton and the Potsdam, the Calciferous being absent, at St. Ambroise 55 miles northwest of Montreal.[2] Mr. C. D. Walcott finds a similar interruption or unconformity by nondeposition between the Potsdam and Chazy, the Calciferous being absent, east of the Adirondacks.[3] Mr. S. W. Ford described near Troy a limestone conglomerate much resembling that of Ashley hill, interbedded with evenbedded limestone, with Lower Potsdam fossils both in the pebbles of the conglomerate and the bedded limestone, indicating, as noticed by Mr. Walcott, "a subjection of the limestone to wave action after consolidation" during the Potsdam or toward its close.[4] The Ashley hill Cambrian limestone conglomerate and breccia (see p. 312) point to a similar event during Lower Cambrian time.

All these facts indicate oscillations in the level of the coast line during Cambrian and Lower Silurian times in eastern New York and the Province of Quebec. It is possible that the frequent alternation of coarse arenaceous deposits and conglomerates with fine argillaceous sediments, which made the grits and slates of the Rensselaer plateau, may also be due to such oscillations of level.

Mather regarded the grit of Rensselaer county as the equivalent of the Shawangunk grit of the Shawangunk mountains in southern New York and held it as conformable to the Hudson River slate.[5] Hall considered the Oneida conglomerate and the Shawangunk grit identical and as resting conformably upon the rocks of the Hudson River group. He described the formation as extending from the Shawangunk mountains into the Blue or Kittatiny mountains of New Jersey, and thence through Pennsylvania and west Maryland into Virginia, and as forming distinct topographical features.[6]

The facts here adduced show that the Rensselaer grit occupies the

[1] R. W. Ells, in Second Report on the Geology of a Portion of the Province of Quebec. Geol. and Nat. Hist. Survey of Canada; Annual Report, new ser., vol. III, part III. Montreal, 1889, pp. 81K, 120K. This observation corroborated by C. D. Walcott in Review of Ells's Report on the Geology of a Portion of the Province of Quebec. Am. Jour. of Sci., 3d ser., vol. XXXIX, p. 111. February, 1890. See also R. W. Ells in Trans. Roy. Soc. Can., Sec. IV. 1891, p. 105.

[2] Wm. Logan: Geol. Survey of Canada. Report of Progress. Montreal, 1863, p. 295.

[3] C. D. Walcott: Classification of the Cambrian system of North America. Amer. Jour. of Sci., 3d ser., vol. XXXII, p. 145, 1886.

[4] S. W. Ford: Notes on the Primordial Rocks of Troy, N. Y. Amer. Jour. of Sci., 3d. ser., vol. II, p. 32, 1871.

C. D. Walcott: Second Contribution to the Studies on the Cambrian Faunas of North America. Bull, U. S. Geol. Survey No. 30, pp. 26-27, 1886.

[5] Op. cit., pp. 368, 382, 384. The pebbles of the Shawangunk are mostly quartz and the formation is not half as thick as the Rensselaer grit.

[6] Paleontology of New York, vol. II, p. 1, 1852.

same stratigraphical position as these grits and conglomerates and therefore belongs to the same age. Its continuation into western Vermont will be considered in the Appendix.

The pebbles of the conglomerate of the grit of the Rensselaer plateau indicate that these grits belong to a period of real unconformity, and not to one of unbroken transition from the conditions of the Lower Silurian to those of the Upper Silurian, such as Logan describes at Anticosti.[1]

[1] Geol. Survey of Canada. Report of Progress, p. 298, 1863.

STRATIGRAPHICAL RÉSUMÉ.

[This table embodies the stratigraphical, petrographical, and paleontological results.]

Age.	Formation.	Description of rock of strata.	Mineral or rock or pebbles.	Age of pebbles.	Fossils.	Age of fossils.	Thickness (estimate).
Oneida Conglomerate (Upper silurian).	*Srg.*	*Metamorphic grit or "Graywacke,"* of greenish color.					*Ft.*
	Rensselaer grit.	The groundmass of fragments of *quartz, orthoclase, plagioclase, microcline, biotite, garnet, tourmaline, zircon, magnetite, titanite, ilmenite, epidote.* Together with *muscovite* and *chlorite*, formed mostly in situ, and *secondary quartz, calcite*, and *epidote.*	*Quartz* (vein or homogeneous).				1,200–2,000.
			Orthoclase, Plagioclase, Microcline.	Pre-Cambrican or Cambrian, Gneiss or Granite.			
			Gneiss, fine banded	Pre-Cambrian			
			Gneiss, white granitoid, with secondary calcite.	Pre-Cambrian			
			Gneiss				
			Quartzite, white, red, black	Cambrian			
			Slate, black, with detrital quartz; feldspar.	Cambrian or Hudson River.			
			Slate, gray	do			
			Limestone, with grains of quartz and feldspar.	Cambrian or Hudson River.			
			Diabase or *Gabbro*	?			
		This Grit is interbedded with greenish or reddish *slates (phyllites)*			Small fucoids or annelid trails.		
	Hudson River or Trenton limest.	The Grit near Tackawasick pond is underlaid by 70+ feet of *limestone*, with clastic grains of feldspar			Monticulopora. Murchisonia... Calymene... Orthis of plicatella type. Crinoids	Trenton or Hudson River.	

Hudson River (Lower Silurian).	*Sha*	Hudson River shales. Shale facies of H. R.	*Shale* (*phyllite*), greenish, reddish, or grayish, with thin strata of fine-grained feldspathic *quartzite*. In places with *black shales*, sometimes calcareous and ferruginous.		Large trails or fucoids.	1,200.
					Graptolites	Hudson River.
			In places with small beds of *limestone* or with *grit*.		Leptæna sericea. Strophomena. Murchisonia. Pleurotomaria. Trilobites. Crinoids	Hudson River (Trenton).
	Sb.	Interchange schist. Schist facies of H. R.	*Schist*, greenish, purplish, or gray, of muscovite (sericite), chlorite, and quartz, rutile (TiO_2) needles abundant, ottrelite, magnetite, pyrite, decomposed limonite (manganese ore in purple schist), tourmaline, rarely albite, veins of quartz, chlorite, and siderite. This schist passing into a gray or black Phyllite (roofing slate in places), of plates of muscovite, sericite, and chlorite, with rutile needles (black iron ore or graphite in black slate) and sometimes small clastic grains of quartz and feldspar, veins of quartz, calcite, and pyrite in black slate.	Rarely small pebbles of *blue quartz*, *plagioclase*, *orthoclase*.		200–2,000.
				Pre-Cambrian, gneiss.	Graptolites in black slate.	Hudson River.
Trenton (Chazy, Calciferous, Cambrian).	*Cs.*	Stockbridge limestone.	*Limestone*, bluish or white, more or less crystalline or quartzose, with veins and nodules of calcite and quartz. The quartzose limestone contains clastic grains of quartz and orthoclase, plagioclase and microcline.		Orthis. Solenopora compacta. Murchisonia gracilis.	1,000–1,400.
						Trenton.
						Camb'n.

GENERAL OBSERVATIONS.

A comparison of the foregoing table with the general section and the appended Greylock section makes the general results clear, and also suggests the following observations:

(1) The absence of the Bellows-pipe limestone and Greylock schist horizons west of the Greylock mass is very noticeable. It may be accounted for by supposing greater sedimentation and greater subsidence in the Greylock area, which, as will be seen from the geology of the Greylock sheet, seems to have corresponded to a bay between and close to the Clarksburg and Hoosac masses.

(2) There is a decrease in the number of closed and overturned folds west of the Greylock mass. This would be expected in proportion to the increase in distance from the resisting crystalline core of the Green Mountain range.

(3) There is an increase in coarse clastic grains in going west from the pre-Cambrian mass and also a decrease in metamorphism. Thus small clastic grains occur on East mountain, larger ones near Perry peak and along the eastern edge of the plateau, but the coarsest ones occur near the western edge of the plateau (loc. 191 and 562). Again, the Stockbridge limestone is more crystalline and micaceous along the east foot of Greylock than in any of the valleys west. The schists of the Taconic range pass into phyllites at the Berlin valley. Secondary albite, so abundant in the Berkshire schists of Greylock, occurs only here and there on East mountain and but very rarely, if ever, on the west arm of the Taconic range, and not at all on the plateau.

On page 310, specimens are described by Mr. Wolff from the grit in which "the pebbles are in process of absorption into the cement."[1] It is, therefore, possible that the general absence of clastic grains on the Taconic range (except that noted near Perry peak) and on Mount Greylock is due to such metamorphic changes and not to the greater fineness of the original sediments in those masses. As to the large albite feldspars formed in situ in the "Berkshire schists" and "Greylock schists," Mr. Wolff states that "he has long suspected that they may have formed in the place of old detrital feldspars, probably larger, which have in part been absorbed in the mica of the rock and part remade into albite."[1]

Instead of the clastic grains increasing in size in the Berkshire schist as we approach the pre-Cambrian crystalline mass, they decrease. This, then, can be accounted for either by supposing, as explained above, an increase of metamorphism toward that mass or else by supposing strong westerly, northerly, or southerly currents in the Silurian seas or the presence in Lower Silurian time of some now concealed pre-Cambrian land mass farther west than any now known.

Whatever may have been the facts as to the sediments, it is evident

[1] See J. E. Wolff: Metamorphism of clastic feldspar in conglomerate schist. Bull. Museum of Comparative Zoöl, Cambridge, Mass., vol. XVI, No. 10, 1891.

that the beds were subjected to great compression near the pre-Cambrian mass, and that there also metamorphic processes were more powerful. But it is not supposed that conglomerates with Cambrian quartzite pebbles, like those of Bowman or Black ponds, occurred in the schists of Mount Greylock or of the Taconic range, as it would involve the unconformity of these masses to the Cambrian, of which there is no evidence.

(4) The general section and the subsections show why the Berkshire schist and the Rensselaer grit might be regarded as synchronous; but the indications of unconformity afforded by the areal relations of the grit to the Stockbridge limestone and the evidence of the unconformity of portions of the grit mass to Cambrian, if not to Lower Silurian rocks, shown by its pebbles, determine them as unconformable deposits. Therefore the grit is considered as representing something more recent than the Hudson River period, i. e., the Oneida conglomerate, the base of the Upper Silurian.

The close of the Lower Silurian period was followed by a great orogenic movement which corrugated the Berkshire schist and the underlying formations and exposed them to erosion. A subsequent submergence, accompanied perhaps with minor oscillations of level, caused the deposition of the Rensselaer grit and conglomerate and the interbedded argillite. A second orogenic movement occurred in Upper Silurian time, folding the grits and the underlying series, obscuring traces of the previous unconformity, and raising the grits above sea level. Dynamo-metamorphism accompanied both of these movements, particularly the first, and then especially in the vicinity of the pre-Cambrian core of the Green mountain range. The eruption of the felsite in the northern part of the plateau occurred during the second movement. The oscillations of level which mark this region began to manifest themselves slightly in Cambrian time, as is shown by the Cambrian limestone conglomerates.

The views of Mather and Rogers, announced in 1841–'42,[1] both as to the structure and age of the rocks of the Taconic range, the Berkshire schist, are substantially verified; and Mather's italicized statement, "that the Taconic rocks are the same in age as those of the Champlain division (Hudson river), but modified by metamorphic agency,"[2] meets with confirmation at the hands of modern petrography, paleontology, and structural geology; and so do Mather's and Hall's views as to the age of the grit.

GEOLOGICAL AND TOPOGRAPHICAL.

(*a*) A comparison of the topography of the Berlin and Troy sheets with the geology of the special map, herewith, and general section shows that the Taconic ranges are parallel with more or less complex schist

[1] Op. cit.

[2] Geology, first district New York, 1843, p.

synclines, and the valleys with limestone anticlines of like structure. A system of E.–W. valleys across the folds of the Taconic range, more dominant on its western and longer side, as they are, also, on the west side of Greylock, imply a vast amount of erosion and of time. As their course is opposite to the general direction of glacial movement, they can therefore owe little to its action. They are of vast antiquity.

(*b*) The grit plateau owes its general form not only to the massive character of its rock and the softness of the underlying rock, as is frequently the case with table lands, but also to its synclinorial structure and its NNW–SSE trough structure. As most of the rocks of the plateau are much harder than those of the Taconic range, the E.–W. valley of the Poestenkill and the deep incisions in the western edge, through which both the Poestenkill and the Quackenkill flow, must represent more powerful or longer acting erosive agencies than incisions of the same size in the Taconic range. The limit of the Poestenkill incision and the inconsiderable stream which now flows through it in summer are shown in Fig. 35.

Have we in the nearly level surface of the grit plateau a base level of erosion dating far back to some post-Silurian time, as Davis makes out for portions of western New Jersey?[1]

The eastern, southern, northern, and the greater part of the western limits of the grit mass follow the topography closely.

As the upthrow produced by such a fault, as might be inferred from the relations of the Ashley hill Cambrian beds to the Berkshire schist on the east, would affect not the plateau, but the valley, such a fault would not account for the steep west edge of the plateau. This must be due either to a fault with an upthrow on the east or to the erosion of the west edge of the synclinorium, or to both, and perhaps in part, also, to the local character of the coarse sedimentation.

(*c*) The difference in erodibility, and therefore in topography and in agricultural value, between the plateau and the Hudson and Berlin valleys seems to be due to this difference in the sediments, the coarse clastic grains diminishing and the fine argillaceous material increasing in the valleys.

The three topographical belts described at the beginning correspond as follows: The Berkshire Hill country to the Berkshire schist and the Stockbridge limestone, the Rensselaer plateau to the Rensselaer grit: the Hudson valley mainly to the Hudson river shales.

[1] W. M. Davis: The geological dates of origin of certain topographic forms on the Atlantic slope of the United States. Bull. Geol. Soc. Am., vol. 2, p. 541, 1891.

APPENDIX.

ON THE CONTINUATION OF THE RENSSELAER GRIT IN VERMONT.

The abrupt termination of the grit of the Rensselaer plateau both on the north and south, and the presence there, instead, of the Berkshire schists and phyllites, are striking. This may be explained either by supposing a discontinuity in the deposition of the grit or their erosion from a very large area. The first of these hypotheses finds some confirmation from observations in Vermont.

The geologists of the Vermont survey[1] allude briefly to the peculiar form of Bird mountain (alt., 2,500 feet) in the Taconic range in the southwest part of Castleton, Vermont, and to its tough quartz con-

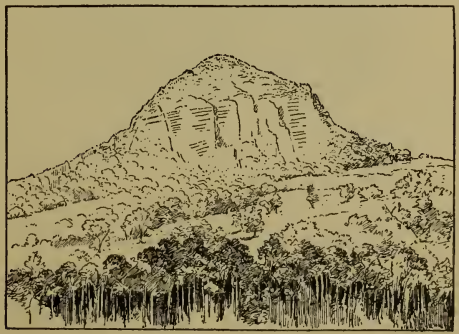


FIG. 38.—Bird mountain, in Castleton, Vermont, looking along the strike, northeast, showing the northwesterly dipping grit strata on a vertical joint face. From a photograph and sketch.

glomerate which on their map and section they place in the "Talcoid schists," the Berkshire schists of this paper. This mountain was visited in September, 1891. Fig. 38 represents its outline as seen along the strike.

It belongs to a subordinate line of hills of the Taconic range and parallel to it, lying west of the mass which forms the west side of the West Rutland valley. From this mass it is separated by high valleys running both north and south from the Castleton river valley. This line of conglomerate hills is broken first, by the Castleton river cut, and

[1]Geol. Rept. of Vermont, vol. II, p. 888, and sec. VI, pl. XVI, 1861.

second, about 3 miles south, by a shallower cut. Bird mountain is the portion between these two cuts. On its south side it presents (see Fig. 38) vertical joint faces striking N. 60° W., but the conglomerate recurs both in the cut on that side and on the next summit south. The rock resembles the Rensselaer grit in its greenish color and calcareousness, and in the presence of pebbles of quartz, bluish and pinkish, and of limestone, but differs from it in the absence of feldspar pebbles, the presence in places of pebbles of a limonitic rock and the "predominance of green chloritic mica in the cement." Fig. 39 represents an enlarged microscopic section of a typical specimen of this conglomerate.

FIG. 39.—Microscopic section of Bird mountain conglomerate, Castleton, Vermont. The pebbles are quartz. Enlarged 2¼ diameters. From a photograph.

Mr. Wolff's description of slides follows:

The large quartz pebbles often show signs of great compression; their outline is often ragged by encroachment of the cement. Part of this quartz is derived from veins, the major part is in single uniform grains and probably in part from granite or gneiss.

The limestone pebbles are granular calcite surrounded by secondary calcite with a columnar crystallization. The dark pebbles are a dark brown limonitic mass inclosing flakes of muscovite and chlorite. One slide contained a large clastic grain of tourmaline, another a pebble of quartzite with calcite cement. The cement consists of chlorite flakes, muscovite (sericite) quartz, partly secondary, calcite in grains and vein-like masses with a columnar crystallization, some grains of pyrite, magnetite and titanite. Small areas of limonite in the rock inclosing grains of quartz may be fragments or represent limonitization of the cement. Other areas looking like pebbles are composed of massive chlorite and little grains of quartz, but they run off in stringers into the cement, therefore may not be pebbles.

The strike of the grit is N. 45° to 60° E.; dip, 25° to 60° NW.[1] Dark gray and greenish slates occur along the west foot of the mountain, and the regular Taconic slates and schists (Sb) form the masses east of it. There is little doubt that the Bird mountain grit and conglomerate occupies the same stratigraphical relations to the schists of the Taconic range east of it as the Rensselaer grit does to those of the same

[1] A quarry has been opened in the grit on the east side of the mountain. The stone is used for monuments but called "granite."

range in Massachusetts and New York. It indicates also a like unconformity to pre-Cambrian granites and gneisses and Cambrian or Lower Silurian limestone.

In the expectation of again finding the conglomerate, an excursion was made from Danby Corners in the Tinmouth valley across the entire Taconic range mass, which here measures 7 to 8 miles in width, to Pond mountain near Lake Austin in Wells, which lies about 10 miles south-southeast of Bird mountain, but only the schists and slates of the Berkshire schist horizon were found.

Pond mountain consists of greenish phyllites, striking N. 45° E.; dip. 40° to 50° SE., and forms part of a line of hills presenting an abrupt face to the west and thus resembling the west face of the Rensselaer plateau. (See Fig. 40.) Mr. Wolff describes a slide of the Pond mountains phyllite as consisting of muscovite, chlorite and quartz with abundant rutile needles, occasional small grains of feldspar and the

FIG. 40.—The western edge of the Taconic range in Wells, Vermont, from a point near the eastern shore of Lake Austin (St. Catherine) looking south-southwest. The high mass on the left, Pond mountain, consists of easterly dipping slates. From a photograph.

usual cleavage phenomena, all so characteristic of the phyllites of the Berkshire schists of the Taconic range.

Although in the Vermont report these slates are called "Georgia slates," they are described as interstratified on the east with the "Talcoid schists" (Berkshire schists) to which they probably belong, the difference being merely due to a slight decrease of metamorphism.

Prof. C. B. Adams's[1] view, that this line of hills and ponds extending from Sudbury to Wells, 25 miles, was due to a line of fracture, not great enough to bring up any of the underlying formations, is well worthy of consideration.[1] (See pages 314, 336.)

A mile or two east of this line of hills and cliffs is another row of conspicuous hills—Moosehorn in Wells, and Bald Hill, Haystack, and

[1] C. B. Adams: Third Ann. Rept. on the Geol. of the State of Vermont. Burlington, Vt., 1847, p. 12 "The line of ponds which extends from the south part of Sudbury through Wells, was found to occupy the place of a long fracture and uplift of the slate formation, the mural face of which, fronting to the west, is found on the eastern margins of the ponds, and with scarcely an interruption for the whole distance. It is worthy of notice that notwithstanding the magnitude of this fracture and uplift, no other formation is thrown up to view."

Indian hill in Pawlet, all consisting of green phyllite, much like that of Pond mountain,[1] and dark-purplish phyllite, like that described on page 306, and also used for paint. Haystack mountain, Fig. 41, deserves notice.

Seen from the southwest, in the line of the strike, it presents abrupt cliffs, several hundred feet in height, formed by vertical joints striking N. 45° to 50° W. The stratification, striking N. 50° E., of this end of Moosehead and probably of this whole line of hills is about horizontal, but in small plications crossed by a cleavage-foliation (Ausweichungs-clivage) dipping 60° to the eastward; and it is to this steep cleavage and to the vertical northwest to southeast joints that the mass owes

FIG. 41.—The southwest side of Haystack mountain in Pawlet, Vermont, seen along the strike. From a photograph. Structural diagram for the mass.

its chief outlines (see structural diagram, Fig 41) and not, as might be expected, to a sharp, closely-folded syncline.

These observations in western Vermont, taken together with the abrupt northern and southern terminations of the Rensselaer plateau in eastern New York, and the frequent interbedding of the grit and slate on that plateau, point to the intermittent character of the sediments which produced the Oneida conglomerate in those regions, and indicate that some of the schists and slates forming the western part of the mass of the Taconic range may possibly take the place of the grits and conglomerates, and have suffered greater erosion.

NEWPORT, R. I., *February 4, 1892.*

[1] Mr. Wolff describes a slide from Haystack mountain: "An aggregate of interlocking quartz with some plagioclase feldspar grains, greenish muscovite, and a nearly equal amount of chlorite flakes. Rutile needles swarm; an occasional grain of apatite and crystal prism of tourmaline."

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